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JOURNAL OF
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VOL. 118
1955

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CONTENTS

VOL. 118—YEAR 1955

Part 1, 1955

	PAGES
The Macmillan Gap. The Inaugural Address of the President, THE RT. HON. THE LORD PIERCY, C.B.E.	1–17
Proceedings of the Meeting	7–11
Current Population Problems, with particular reference to the United Nations World Population Conference. A Discussion opened by B. BENJAMIN and others	12–27
Measuring Unemployment. By H. A. TURNER	28–50
The Pattern of a Divided Economy: A National Income Analysis of India and Pakistan. By R. H. KHANDKER	51–55
Measuring Social Mobility. By S. J. PRAIS	56–66
Statistics Bearing on Financial Investment. By J. I. MASON and D. SACHS	67–100
Reviews of Books	101–120
Statistical and Current Notes	121–123
Obituary:	
L. Rostas	124–125
B. Seebohm Rowntree, C.H.	125–126
Statistical and Economic Articles in Recent Periodicals	127–130
Additions to Library	131–137
Periodical Returns: Bank of England Weekly Return, 1954	138–139

Part 2, 1955

	PAGES
Net Investment in Fixed Assets in the United Kingdom, 1938–1953. By PHILIP REDFERN	141–182
Discussion on the Paper	182–192
The Teaching of Mathematical Statistics at University Level. A Discussion opened by Professor E. S. PEARSON, C.B.E., and Others	193–223
Farm Wages in Central Scotland from 1814–1870. By GEORGE HOUSTON	224–228
Wholesale Prices in 1954. By the Editor of the *Statist*.	229–233
Statistics Available on the Local Government Services. By B. J. BROCKS	234–244
Reviews of Books	245–257
Statistical Notes	258–262
Statistical and Economic Articles in Recent Periodicals	263–267
Additions to Library	268–274

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Part 3, 1955

	PAGES
A Statistical Examination of the Megalithic Sites in Britain. By Professor A. THOM	275–291
Discussion on the Paper	291–295
A Method of Labour Turnover Analysis. By K. F. LANE and J. E. ANDREW	296–314
Discussion on the Paper	314–323
The Statistical Analysis of Congestion. By D. R. COX	324–335
Agricultural Income. By J. R. BELLERBY	336–344
The Scotch Whisky Industry. By Ross WILSON	345–362
Reviews of Books	363–372
Statistical and Current Notes	373–375
Statistical and Economic Articles in Recent Periodicals	376–379
Additions to Library	380–383
Periodical Returns: Registration of the United Kingdom and Eire, 1950–1954	384–387

Part 4, 1955

	PAGES
A Unified Derivation of some Well-known Frequency Distributions of Interest in Biometry and Statistics. By J. O. IRWIN	389–398
Discussion on the Paper	399–404
Colliery Statistics. By F. D. K. LIDDELL	405–416
An Analysis of 162,332 Lottery Numbers. By JOHN H. WEST	417–426
Statistical Assessment of the Need for Clinical Services: Report of a Working Group	427–433
National Income and Related Statistics. By J. E. G. UTTING	434–451
Population and Vital Statistics. By E. GREBENIK	452–462
International Statistical Institute, 29th Session, Rio de Janeiro, Brazil, 1955	463–464
Annual Report of the Council	465–482
Proceedings of the One Hundred and Twenty-First Annual General Meeting	483
Reviews of Books	484–493
Statistical and Current Notes	494–496
Obituary:	
Philip Lyle	497–498
Stanley Jevons	498–499
George Findlay Shirras	499–500
Statistical and Economic Articles in Recent Periodicals	501–505
Additions to Library	506–513
Periodical Returns: Revenue of the United Kingdom, 1954	514
Index to Vol. 118 (1955)	515–517

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VOL. 118.] [PART I

Journal of the Royal Statistical Society

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PART I, 1955.

The MacMillan Gap and the Shortage of Risk Capital

[The Inaugural Address of the President, Lord Piercy of Burford, C.B.E., delivered to the Royal Statistical Society on November 17th, 1954.]

1. *The Macmillan Gap and the Macmillan Report*

The Report of the Committee of Enquiry into Banking, Finance and Credit* which sat under the Chairmanship of Lord Macmillan can still be read with profit and is a convenient mark for assessing the changes which have taken place since then. The Committee made important recommendations on domestic and international monetary policies; but it is remembered especially for the section of the report which dealt with the capital market for home investment. The financial public seized with some avidity on a passage which drew attention to the difficulty said to be experienced by the smaller and medium-sized businesses in raising the capital which they might from time to time require. Nothing in the report attracted such lasting attention as the signalling of this "gap". The question of the organisation of the capital market which it raised may with advantage be looked at in the light of the general observations of the Committee on this subject. These mainly were two.

One of them concerned the facilities existing in the City for the raising of long-dated capital for home industry in general, or, more briefly, the efficiency of the issue market in this field. Excellent as regards the issue of foreign bonds—a business which had revived in the 'twenties—"only one or two first-class houses in the City performed for certain first-class companies the same functions as the older issuing houses performed for foreign borrowers". Otherwise institutions of name and reputation for handling home industrial business were lacking. The Committee commented in scathing terms on the manner and the results of recent flotations, taking the market of 1928 as their text. The fact is, that in their retrospect, the Committee was reviewing the early years of a dramatic change. Interest in home issues was superseding the interest in foreign and overseas issues. Whereas about 1913 home issues were 20 per cent. of the entire volume of issues, and overseas issues 80 per cent., in the 'twenties home issues had risen to 50 per cent. while, of the remaining 50 per cent., less than one-half was foreign issues which formerly had been the staple of the market. To-day the proportions are the reverse of the 1913 proportions, and, in the overseas part, the foreign element has become almost negligible. But the organization of the issue market had not yet been fully developed nor the business put on its proper foundations. All this was largely done in the 'thirties. There was a considerable development of issue houses and more of the merchant bankers had become interested.

Now the business is professionalized; the figure of the company promoter, so prominent in 1920 and again in 1928, has largely disappeared. The Prevention of Frauds (Investment) Act, 1939, and the Companies Act, 1948, played their part. The policing of issues by the Share and Loan Department of the Stock Exchange has developed into a function of great public usefulness. At the same time, the patterns of the operation of the issue market have assumed definiteness, and the limitations as well as the capacities of the instrument are visible. As regards the cost of issues, the costs of publicity and the professional fees are, and must be, substantial, and the burden is heavy in the case of smaller issues. But for a part of the business the burden has been eased by development of the technique of "placing" which in any one of its variants reduces costs. This development has been associated with changes in the structure of the market on the demand side,

* Committee on Finance and Industry, report. Cmd. 3897, 1931.

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mainly the impressive growth of the importance of the insurance companies and other investing institutions and of pension funds.

The second main topic was the relations between financial institutions and industrial institutions. The Committee were impressed by the advantages of the intimate relations which existed between the banks and industry in Germany, and in a different way in America, and the benefits to industry and commerce of this association. They saw nothing of the sort in this country: and were driven to propose the establishment of one or more new institutions to remedy this—institutions which would be a combination of issue house and finance house, commanding large resources of their own. Here, too, the situation has changed; personal links between financial houses and large industrial concerns at Board level now are numerous and visible. This has resulted naturally from the changed attitude of the City towards home industrial business. And, no doubt, this has borne fruit in the way of increasing the access of companies to the capital market. The Committee's institutional remedy has been completely forgotten.

The "gap" however is my theme. It is important to understand exactly what the thesis of the Committee was. The structure of the business world then, as now, held a great preponderance of small and medium-sized concerns. Money, of course, had been raised for over a century by share issues of companies small and large; shareholders were found by many methods, including advertisement, particularly after the final introduction of limited liability; and through diverse agencies—solicitors, bank managers, accountants and others. The constituency of investors, mainly local, which was tapped thus, had become smaller, less rich—because of personal taxation, steeply increased as the result of the war—and less responsive. The issue market had at no time been much concerned with small issues for new money for small companies. The market in home issues was not well organised in the 'twenties as I have remarked, but it was natural for the Committee to consider the possibility of making share issues of small companies through the issue market. They saw two difficulties, the cost per unit of capital raised (a consideration for the company) and the lack of marketability (a consideration for the investor). This left a gap. To remedy this they proposed the formation of a company to devote itself particularly to these smaller industrial and commercial issues. It would require an ordinary capital, but it might well issue preference share capital or debentures secured on the underlying debentures of the companies which it financed. Such debentures (or preference shares) the Committee thought might have a free market. The remedy for the gap therefore was to tap the issue market at one remove.

From the vantage point of 1954 one can see the causes which have accentuated and increased the Macmillan gap and have been responsible for the continued interest in it. These causes are taxation affecting, both by its weight and progression, the structure of incomes and savings, and changes in the forms of personal saving and investment, the former due to such factors as the development of insurance, the latter to the growth of the financial press which increased the prestige of marketable securities.

The contemporary response to the Macmillan Report was notable. It took two lines. One was institutional, divers variants of the Committee's proposal. The other was a direct testing out of the willingness of the market to absorb small issues. Along the first line there was, for example, Credit for Industry Ltd., set up as a subsidiary by United Dominions Trust Limited and assisted for some period by the Bank of England, its object being to make secured loans on long term to small industry. This is interesting as a venture in what might be called strictly industrial banking. The Charterhouse Investment Trust Ltd., a public company which had been founded in 1926, developed a policy of grooming small concerns for issue after a period of nursing. Several well known merchant banking houses started ventures tending to one or other of these patterns, but mostly the latter. These were private companies but backed at least by considerable powers of raising market money. Along the second line, one or two stockbrokers and several issue houses contemporaneously went some way to finding methods of selling small issues to the institutions and creating some market for them with the general public. Issues as small as £50,000 were floated. It may be fairly doubted, however, whether these issues were to any great extent issues to raise new money as distinct from the flotation in whole or part of interests in existing companies.

The Macmillan gap reappeared in the thinking about reconstruction which took place in official circles around 1944. As a measure for providing finance for small and medium concerns after the war a proposal emerged that the joint stock banks should set up a special institution.

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This institution, Industrial and Commercial Finance Corporation Limited, ICFC, was in fact set up in 1945. While it may be fairly said to be a (belated) fulfilment of the Committee's proposal, it presented some salient differences of construction. The most notable was in the provenance of its resources. ICFC does not issue its own debentures or preference shares to the public as the counterpart of its advances to industry. It is entirely financed by banker shareholders. Its resources to be so provided were set within an ambit of £45 millions (£15 millions subscribed as share capital, £30 millions to be made available on loan) the proportion of each shareholder bank being related to its deposits so as to turn the edge of any objection on the score of jeopardy to liquidity. This method of financing the Corporation gave it the maximum chance of establishing itself. Its business consists both in making loans on fixed terms for long periods and subscribing for share capital; and it works as a rule to a low limit of £5,000 and an upper limit of £200,000, its average holding in any company being of the order of £50,000. It has at the present time nearly 500 companies on its books. While it has not been concerned to limit itself to propositions which are likely to turn into issues within a moderate time—rather the reverse in fact—some of its customers have gone to issue, particularly in the last year or two, and this has been done through the regular machinery of the issue market. In size its portfolio seems likely to become balanced at nearer £30 or £35 millions than £45 millions.

After so much history I must now try to make an up-to-date assessment of the reality and importance of the gap and the provision which now exists for meeting it. And first the point must be firmly made that the underlying structure of business in this country has not changed materially. There is a general tendency no doubt to increase of scale capital wise, but the preponderance of small and medium-sized companies remains; these are mostly private companies, often family companies, and they prize this status. The rarity of the casual moneyed investor willing to invest in such businesses has become accentuated. This development has been paralelled by an increased concentration by the investor on quoted issues and the more marketable of these. Granted these points, how far at the present time can the issue market meet the needs of the smaller companies? To get this in correct perspective it is necessary to recognize a major background factor; that is, the secular stream of flotations of private companies increasing when the market is on the feed, diminishing to small dimensions at other times. The motives are various. In a small minority of cases flotation represents a step towards expansion in size and activity Here new money may be raised in the market from the original operation or later. In most instances it represents a complete or partial selling out of the interests of the existing proprietors, a step which may be original, or induced, or may be prompted by the pressure of death duties. The market, when on the feed, likes these flotations; there is usually some profit for all parties, and, in the circumstances, the expense of the operation is not greatly felt. Nevertheless, the stream is small in relation to the total number of private companies, and it is selected. There are many conditions to be fulfilled for an operation in the issue market to be practicable for a small company. It does not, therefore, follow that the stream of what might be called new capital directed to small companies is large or growing; and where it is a question simply of new money the costs of issue become a consideration. It may indeed be a more important point that the proceeds cashed in by the shareholders assist the supply of personal private funds that are available for investment.

The growing importance in recent times of the funds of the institutions, mainly the insurance companies, but more recently, too, the pension funds, has a bearing upon the question. The interest of insurance companies in ordinary shares which had hardly taken its rise in the latter 'twenties has become a major market factor; and, paradoxically, they have become a substantial support to the small issue. For an issue to be suitable to the general investor it must have long-run marketability; and this is a function mainly of the size of the issue. Marketability is not so important for institutions.

Institutions—more exactly, the insurance companies, and to a much smaller degree a certain number of investment trusts—have abated to some extent their requirement of marketability. But only to a limited extent. The recent activity of the institutions in the field of small issues is rather strictly limited. It is not very often that they will be interested in the equity of a small business; and the inducements, including the stability of the concern, its management and its prospects, must be very attractive for them to do so. When it comes to preference shares or long-term loans, the insurance company is inclined to insist upon provisions as to redeemability

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which are not always convenient. It may fairly be said, therefore, that while the work of the issue market as shown by the immense number of quoted securities, has long bulged over the frontier between shares in which there really is a market and shares in which the market is limited or non-existent, and while there will always be the stream of small flotations for the motives described, it remains true that for the bulk of the country's small and medium-sized businesses, the issue market is not a really practicable source for the raising of long-dated capital. Nor is it in the ordinary investor's interest that it should be too much resorted to for small issues.

On all the foregoing counts, the contemporary situation, while different in degree and detail, is not broadly or basically different from that seen by the Macmillan Committee. Structurally, the gap is still there. As to its width and depth, it seems to me that there has been one change which might almost be called structural. This is in the part played by the banks. This consists primarily in the much greater normal resort by small private companies to bank advances as a regular method of financing. One still finds private companies which are opposed in principle to any indebtedness to the bank; but the banks' figures I believe show a dependence of small companies on bank loans and overdrafts which is substantial and exceeds the dependence of large companies. And, of course, it is an obvious truism that liquid resources, in an important degree, will economise fixed resources. There has been also in recent times, perhaps mainly in the last decade, a change, not widely remarked but real, in the attitude of the banks towards lending. This change has been discreetly expressed by Mr. Clemens, a recent writer on bank lending. The banks, he says, "are prepared to lend to-day less conservatively, though always with due regard to the national interest." On the other hand, in the last resort, the function of the banks is not, and cannot be, the provision of permanent or quasi-permanent capital. They do not lend for long periods on fixed terms of repayment, nor take up industrial issues.

How big is the gap, allowing for this? The demand it sets up is for capital resources for new enterprise, for development, and for adaptation to changing economic or technological conditions, which cannot be met from the retained profits which in practice provide much of this. As such it must vary from time to time; but it may be expected to be, and it is, more or less continuous. I would deprecate any attempt to measure the size of the demand by the sedate and solid progress of ICFC; first because ICFC was established in a field where there was already a certain amount of activity. Secondly, because in the circumstances of the last few years, the example set by ICFC has proved a powerful stimulus to other institutions, large and small, to enter this field. It may be possible that ICFC has done even more for the gap by example than by its exertions.

To conclude this theme, the gap is real enough, and when the need is for permanent or quasi-permanent capital, there is a quantity of various facilities outside the issue market for coping with it. More, perhaps, could be done to make the range of these facilities better known to the business man and his professional advisers; but this point could be exaggerated. There remains a difference in the particular efficacy of institutionally provided finance as compared with the casual well-to-do investor, particularly the investor who knows the business in which he invests. Institutions, for reasons which go deep, will always tend to rely largely on proved performance as a basis for supplying funds or taking up securities, thus some concerns will find it a little difficult to repair their structure if funds are withdrawn or losses encountered, or even to expand resources to meet requirements for additional monetary sources if inflation occurs or trading methods change. On the other hand, where the institution is prepared to do the business, it will usually do it adequately.

2. *A Shortage of Risk Capital?*

To-day's preoccupations in respect of the capital market differ from those of twenty years ago; among these preoccupations the most popular though not the most profound is the idea that there is a shortage of risk capital or venture capital. The difficulty in considering this idea is its elusiveness. Is the proposition the shortage of capital available for venturing, or an unwillingness to venture?

The simplest form of the idea is the opinion that there is difficulty in securing the subscription of capital for industry in the form of ordinary shares. This might seem to refer the matter to the experience of the issue market and the stock market to which it is so closely related. Here, apart from external circumstances, an unusual measure in recent years of abnormal conditions and policies must be allowed for. These include restrictions on new issues, including capitalization

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issues, limitation of dividends, the Excess Profits Levy, the developments of Profits Tax, and, besides all this, the massive exchanges of industrials for governments and of compensation stocks for higher yielding investments which resulted from the Nationalization measures, and more recently the release to the market of quantities of steel stocks. All this must be borne in mind in applying the appropriate tests, which I suppose are two.

One is the rates at which ordinary share capital has been raised. Are these excessive as compared with the past? Allowing for the variation in rates which takes place between periods of lesser and greater activity in the markets, this test gives a negative result.

The other test is the spread between the yield from less and more risky forms of investment, viewed as a premium for industrial risk. The classic comparison is between British government securities and good ordinary shares. Here again there is no significant indication. The method can be extended to examine the spread between yields on industrial investments of varying grades. Here a wide range of yield will be found, with some good-looking names of companies among the high yielding stocks; but the spectrum of yield is not vastly different from what it was. Finally, some comment has been made on the practice of the investor—more commonly now, it is suggested, than in the past—to look not simply at the dividend yield on his investment but also at the so-called earnings yield. A good margin of earnings over dividend paid is certainly one of the tests of a reliable equity investment; but the investor's demands here, too, vary with the activity of the markets; and the margin of earnings disclosed in new issues and on established investments alike has lately run off considerably. Here, too, there is no corroboration of a greater unwillingness on the part of the investor to take risks now as compared with the period before the war. The features of the stock markets and the new issue market, in short, seem to me to give no positive indications of a shortage of risk capital in this context.

It is better, I suggest, to look at a different point of the economic system for evidence of a shortage of risk capital. For this purpose a distinction may conveniently be drawn between a market in securities and a market in risk-taking. The foundation of the market in securities is the device of the negotiable security as a source of income more or less reliable and—in the case of variable income securities—possibly a hedge against inflation. The speculative element, turning on fluctuations in market prices or the prospect of capital appreciation, is something superadded to this. Thus, essentially, the interest of the investor, whether a member of the public or an investing institution, is focused on the characteristics of the security and the market, not on plans and policies of the undertaking. In the case of the investment manager, patterns of institutional investment play a part in his operations. On this view the market in securities, in which all the new issues of capital must find their place or their reference, is a phenomenon at least one step removed from the actual function of risk-taking or venturing capital.

Let us shift our view from the stock market to the operations of the entrepreneur himself. Risk-taking for the present purpose consists of decisions taken within the ambit of private industrial or commercial operation. The nerve of these decisions is a highly personal sensitiveness to gain and loss, above all in respect of the capital amounts committed. Is there any distinction to be drawn between large public companies, where the managers are apt to be a self-perpetuating group of persons with little or no individual stake in the capital of the undertaking, and private concerns where the managers may be large proprietors? This is a question of some significance, since traditionally it is the latter that has been associated most with the idea of entrepreneurship; and there are salient differences between the two types, even though the one merges into the other. On the basis of personal experience I should be inclined to answer this question in the negative. The sentiments of responsibility which in the one case rest on personal and family ownership of the capital, are replaced in the other by equally effective motives. Apart from the interest of the directors in the maintenance of their own positions, strong sentiments cluster round the public reputation of the company and the maintenance of the dividend. There is not much difference in the quality of the profit motive which is the primary motive of activity and investment. It may be even that nowadays it may operate with a greater boldness in the large public company than in the established private company—where a balance of personal considerations may counsel timidity.

The funds available for commitment at this point of the system are by no means limited to the proceeds of new issues through the issue market. They consist to a large extent of company reserves, arising from retained profits and depreciation reserves. For a private company with little or no access, or no easy access, to the capital market these funds may nevertheless be aug-

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mented from other institutional sources of capital. There are always the banks; and when a company is sound and there is flexibility in its financial structure the bank may provide substantial funds and make such funds available for appreciable periods. Anticipated profits may also be brought into the budget. Thus on the broadest view there is at any time considerable command of capital for risk-taking. Now it may be argued that in the decade since the end of the war the totality of resources available to the entrepreneur has, by some standard of needs, been too low. This might especially be urged having regard to the heavy demands for restoration and replacement following on six years of war. On this I would argue that a shortage of capital is not the same thing as a shortage of risk capital. Even replacement involves risk-taking, especially when replacements are made at an increased cost. The proposition might be true if it could be sustained that where there is a shortage of resources, the resources will be applied to the least risky employments. It seems to me to be obviously untrue; the resources will be applied to the employment which seems to be the most profitable. The best that can be done, therefore, apart from a more or less refined presentation of instances, is to consider some of the general conditions which—other things equal—may have affected the readiness to undertake risk or uncertainty. Among the major long run influences two stand out: the effects of full employment and of taxation.

The state of full employment has lasted with only a little wavering ever since the war. It has masked important transfers of resources from one industry to another and it has concealed some hard spots of unemployment. It may be that its prime support has been the post-war levelling of real incomes which has set up a domestic consumers demand, which has not even yet probably reached its full development. Even if this gives food for thought, domestic demand is only half the story; there has been a compensatory relationship between domestic employment and export, and to a limited extent, I suppose, between export and the supply of investment goods at home. In this setting, despite recurrent crises over the balance of payments, confidence has been high and profits good. It has been, and still is, a condition in which risks are taken with a certain equanimity.

Post-war taxation in respect of its continuing weight is a new social feature. It is currently regarded, in its incidence on business, as deterrent to enterprise. It is not possible to follow the subject into all its ramifications. For instance, it is said that high personal taxation tends to reduce the initiative and damp the ambition of business executives and to make them security-minded. This I must leave on one side. There are some features of recent tax legislation, such as the structure of Profits Tax and some of the conditions by which it is surrounded, which are thought to hamper company policy. This topic also I must leave. It is perhaps worth observing that there is a certain impact from personal taxation on company policy in the case of the private company, especially the controlled private company. Liability to Surtax under Section 245 and the method of assessing death duties upon the estates of the individual shareholders alike have some effect on the willingness of companies to expand and to invest. Perhaps the actual weight of estate duty on large shareholders may be the chief factor; but it is true that a certain tendency can be discerned in private companies towards disinvestment or at least reducing the stake of large shareholders.

In general the depressing effect of taxation on companies is overstated. Companies have borne with a certain ease the heavy taxation of recent years, including the arbitrary temporary impost, Excess Profits Levy. It may be argued that high taxation is a condition which within limits is favourable to risk-taking by firms making ample profits; and so it is as regards certain forms of expenditure. The chief deterrent effect of high taxation is on heavy or long-term capital expenditure, above all on heavy specialized capital expenditure. I am speaking, of course, of the sphere of private enterprise; public undertakings and nationalized industries fall outside this. And I am not forgetting the massive investment programmes of some large companies, or the substantial expenditure that has been made in a few industries such as the chemical and petroleum industries. But I am convinced that generally and in manufacturing industry at large high taxation encourages, in this matter, short views. Fortunately the remedy is very largely in the hands of the Revenue; it is to allow capital expenditure to be freely and boldly written off against profits. The British tax system here is unduly conservative. On static assumptions, and with certain exceptions, the rates of depreciation which are allowed for income tax answer moderately well to the physical obsolescence of assets. They do not, however, correspond well to the prudential considerations which enter into risk; and the whole system is infected by problems of inflation and increased replacement costs. The one feature of all future taxation that is fairly certain is that the taxation of company profits will not be relieved. The taxation of profits is an easy resort for any Chan-

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cellor; and the State already takes in tax more than one-half of company profits if we take into account the income tax which is deducted from dividends. This is a situation in which a liberal policy by the Revenue is not only reasonable but, in the long run, would be profitable. A good deal can be learned from the practice of America and of Sweden, countries both modern but with very different régimes, as to what can be done appropriately in this direction.

I may seem, by these generalities, to have disposed of the question of innovation or at least to have smuggled it away. Expenditure on research, the investment of capital on experimental projects, the designing of new forms of enterprise and even the starting of new enterprises which give scope to the energy of forceful and inventive individuals, are among the most essential forms of risk-taking. Innovation was always a wild plant. It is a paradox that some of it may be produced by system. Thus the research activities now common in industry, and assuming massive proportions in some of the larger companies, provide a substantial quantity of new inventions and methods, and the means of testing many new projects. It is no longer left entirely to the isolated inventor and the spirited capitalist. Development plans of established concerns provide new industrial tissue; and the ferment in management methods continually creates new scope for industrial ability. The general condition of confidence and profit-making in recent times has favoured all this. This does not, however, exhaust the subject. There is, as there always has been, a type of innovator who because of his personal characteristics must develop his own enterprise, or is left to do so because he cannot convince others of the value of his ideas. Such new enterprise always came to birth with difficulty. It may be that now, when an individual cannot accumulate any substantial capital by savings from earnings and the rich individual investor who is prepared to take a bet has become scarce, the situation is more difficult. Some institutional assistance is available now for the development of new inventions, but not enough to offset these difficulties. To admit all this, however, is not to admit a shortage of risk capital. The subject does, however, bring us back to the tax problem. The tax system is very hard on new enterprise.

I sum up this discussion on the shortage of risk capital by saying that consideration hardly supports the view that there is any great reluctance to accept risk or undertake uncertainty. The pattern of gross fixed investment since the war has been affected by sharp variations in government policy, administrative controls, shortages, the needs of export and other causes, so that I would not even attach very much importance to the relative meagreness of fixed investment in general manufacturing industry. In the one respect where high taxation is likely to have a serious effect on investment the remedy is obvious if not simple. I feel much less confident as to the overall adequacy of capital investment in industry. That however is another subject.

PROCEEDINGS OF THE MEETING

Professor SIR RONALD FISHER (Past-President): It falls to me, in accordance with the traditions of our Society, to express appreciation of the Presidential Address by moving a formal vote of thanks; and indeed, far as the subject-matter lies beyond the field of my own studies, and improper as in any case it would be to discuss the address we have just heard in critical detail, it is easy to perceive, as also a pleasure to emphasize, the learning and authority with which Lord Piercy has handled his important topics.

Reading the address I was greatly struck by the felicity with which the Macmillan report laid its finger on the concept of a "gap", a feature characteristic not only of a particular phase in the evolution of our banking system, but of the whole modern world, or, at least of our modern attitude towards the world, which is perhaps the same thing to a philosopher. Indeed a whole philosophy based on gaps as its central concept, would not perhaps be more idiotic than those of Plato or Kant or Karl Marx. The more we think about them the more gaps there are to be discerned—those chronic gaps in our own incomes, the welcome gaps in the sad continuity of a wet summer, the deplorable but undeniable gaps in our usual form at games of skill, or in our accustomed serenity and good temper. In a world so full of gaps, if that expression is not too paradoxical, one cannot but feel how fortunate are those medium-sized industrial enterprises in that their particular yawning gap, or unsatisfied desire, for permanent capitalization on easy terms, should have become the particular care of the high-powered financial experts among whom Lord Piercy moves.

Through this expert care, I understand, this particular gap has been at least partially filled, and much satisfaction must be felt about this. Yet there will remain, I fear, an endless vista of gaps for their successors to replenish; and since diagnosis and treatment are both evidently very

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lengthy processes, one would welcome, perhaps on some future occasion, some light on the principles on which an order of priority should be established, so that gaps should be recognized, and, if that is the term, *plugged*, only when they are ripe for remedial treatment.

In any case, I am sure that Lord Piercy's wise words will be weighed and pondered by the many financial experts in the Society, and that we shall all join in according him an entirely hearty vote of thanks.

SIR GEOFFREY HEYWORTH (a previous Past-President): It is my privilege to second the vote of thanks to our President. Lord Piercy chose for his address a subject which is topical and indeed has been topical for the past century, and which I suspect will remain topical for a long time yet.

Back in the 1880's, for instance, when Mr. Lever went to the Warrington bankers and asked them to help finance new buildings and plant, they refused. In the end he financed the whole operation himself, but this incident left its mark. He never lost his impatience with the timidity of what he called the "banker's mind". The moral of this story—and there are many others like it—is simply that the lack of finance does not deter the more courageous industrial adventurers. Perhaps I should add that it does not follow that I think that the first Lord Leverhulme would have classed Lord Piercy as a person with a banker's mind.

Unfortunately we know too little about this "appetite for risk". Is it governed by economic, social, psychological or human factors or by a complex mixture of all four? It has been claimed that the current incidence of high taxation has reduced the willingness of individuals to assume risk. This argument presupposes that risk bearing is largely a function of net income.

It could also be argued, equally convincingly, that the appetite for risk has increased, since under our present tax system the proprietor/director has more opportunity for reducing the personal incidence of tax, and thereby making the Government take its share in the risk. I do not know. I am sure Lord Piercy was right when he said that "the new venture had always to be a venture of individuals and that this still remains".

Anybody with bright ideas which are commercially sound will, by some means or other, get them exploited. If there is any significant difference between now and a century ago, I suggest that it is simply this. Whereas in the nineteenth century the person with bright ideas had to find a patron, now he persuades an existing concern to take over and exploit his invention. Although the existing large concerns do research themselves, I think you will find that they also provide a market for the ideas of outside inventors.

Nevertheless it is true that when we look at our present financial system we cannot help being struck by the apparent lack of institutions that provide funds for small business. I am not a banker, but I can well appreciate the reasons for bankers not wanting to keep their money tied up in really long term loans. But this discussion of obtaining finance is merely a discussion of means. The end is investment, and the real test is whether there is sufficient investment taking place and, if not, whether the lack is due to a shortage of financial institutions. The Chancellor of the Exchequer complained only a fortnight ago that Britain was not investing enough—particularly in comparison with other countries. You are probably conversant with the O.E.E.C. figures which show that in 1952 gross domestic capital formation in the United Kingdom was only 12 per cent. of gross national product compared with 25 per cent. in Germany, 18 per cent. for the whole of Western Europe and 18 per cent. in the United States.

Now, as a business man I have to rely more on feel than figures, and I doubt whether investment in Britain at the present time is really lagging behind. These O.E.E.C. figures may be accurate as far as they go, but I do not believe that they are telling the whole story. Of course, 1952 was an unfortunate year and the figures for 1953 might be nearer the truth as we businessmen know it. But in any case 1954 has proved that our major export industries are no less efficient than our competitors', while the rise in national productivity has been of a high order. These facts do not suggest a shortage of investment.

Clearly other factors have to be taken into account when we make statistical comparisons of investment in different countries. In the first place Britain is an old developed country in which the basic services are already provided on an adequate scale. Hence, new productive investment requires less capital per unit of output than in the newly developed countries, where possibly every £1,000 of industrial investment has to be matched by £1,000 of social investment to provide such things as drainage, water, roadways and such like.

Again, because Britain is an old developed economy, its basic industries have perhaps more surplus capacity, so that an extension of capital investment in the later stages of production does not automatically require so proportionately large an extension to capital investment in the early stages as it does in newly developed countries.

Finally, there is a point which is well known to you statisticians but which perhaps escapes our less learned colleagues. If industrial investment is to be measured as a proportion of gross

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national product, then surely as gross national product and the standard of living rise this proportion must tend to decline if the economy is not to suffer from an exuberance of investment.

Britain certainly needs all possible investment which will raise output per man and so reduce unit costs. Perhaps even more important nowadays, because of the relatively higher cost of food and raw materials, is the need for investment which will reduce process wastage and give a higher output per unit of input. Those of us who are responsible for the investment of capital have to discriminate clearly between investment as a means of improving our competitive position and investment for investment's sake. Efficient investment will involve a constant search for less wasteful methods of production and distribution, so that the standard of living can be pushed even higher. For after all, the purpose of investment is to increase consumption, and unless a balance is achieved between investment and consumption the growth of the economy will be impeded.

I feel somewhat worried when I hear different Chancellors of the Exchequer pleading for more and more private investment at a time when the Government is also maintaining a very high level of investment. Is it not wasteful for private and government investment to compete with one another for our slender resources now that unemployment is reduced to a little over 1 per cent.? If private investment is to expand now, should not Government investment be held back as a reserve of demand to sustain the economy when business activity shows signs of faltering? I should have thought that at the present time the total volume of investment in this country was fully adequate. If there is anything wrong, it is perhaps that industrial investment has received too little and social investment too much attention. And housing, I suggest, comes under social investment.

It is unfortunate that in this field of investment, which to some extent is the main-spring of economic activity, reliable statistical data are so scarce that it is impossible to come to any definite conclusion. I only hope that one or two statisticians may be stimulated by Lord Piercy's address to look into this problem and perhaps provide an answer.

I am very glad indeed to have been here today to hear Lord Piercy's address. He has raised points that I think are right in the main stream of the problems to which a great many of us are devoting our minds. He has certainly injected stimulating thoughts into my mind, and I believe this has been the experience of all of you too. I have therefore great pleasure in associating myself with Sir Ronald Fisher in seconding a hearty vote of thanks for his address.

The vote of thanks was carried unanimously.

Professor A. BRADFORD HILL (previous Past-President), who was prevented from attending the meeting, sent the following written contribution which was read by the Honorary Secretary:

I greatly regret my absence from this particular meeting of the Society for it was one from which I expected to derive much comfort. Fellows with an intimate knowledge of the Society's traditions would, I felt sure, derive an equal, or indeed much greater, satisfaction. For this was positively the last occasion on which the Society's Honorary Officers could call upon me to address you from this or any other platform. Traditionally the penultimate President has the privilege of seconding the vote of thanks to the reigning president, but, in Sir Alexander Gray's words, he is by then not merely an ancient monument; he is an ancient monument scheduled for demolition. Lord Piercy may wish to take note of these inevitable ravages of time.

Less comforting was the fact that I must speak to, if not of, the subject of the address that the President has laid before us. I know full well that it is customary to begin by saying that the Presidential Address cannot be discussed; and it is customary to end by moving a vote of thanks. But unfortunately there always has to be a middle part. All the best speeches are built on that model. The usual technique, I note with despair, is for the past presidents to throw in a few brilliant footnotes to what their successor has said. I trust that Sir Ronald Fisher and Sir Geoffrey Heyworth will have done so, for I know so little of the subject so eruditely presented to-day that I would not dare to insert an asterisk in Lord Piercy's text, far less the associated footnote. Yet, being in the mood for confession, I must admit that this was not always so. I once took a degree in economics, I once knew even the riddle of the exchanges (though I cannot recall ever being able to answer it). But—to paraphrase Lord MacMillan himself—more than 30 years have passed since I bade farewell to the classrooms of the University, "the proud possessor of a parchment which testified to the world at large that I had satisfied—or deluded—the examiners". I turned to quite another field of knowledge and forgot the "dismal science" (though I must admit that I never found it that).

The President opens his address by saying that "the Report in 1932 of the Committee of Enquiry into Banking, Finance and Credit which sat under the Chairmanship of Lord MacMillan can still be read with profit". While I was unable immediately to take down a copy from my bookshelf, Lord Piercy did inspire me to take from there and re-read, with great pleasure, some lectures given

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by Lord MacMillan and published by him in 1937 in a volume entitled *Law and Other Things*. Whether we are interested in the law or not, most of us as citizens could profitably read those philosophic and beautifully written disquisitions. In some ways—they suggest to me—the statistician and the lawyer must often come very close together in their ways of thinking, in their ways of marshalling evidence and in drawing conclusions. Both must reduce a mass of material to manageable and intelligible proportions, both must sift the essential from the inessential and bring order out of chaos, both must, in the end, pronounce judgment upon the most *probable* explanation of the matter before them. For instance, of the lawyer Lord MacMillan writes: "I find myself daily more convinced that of all the equipments of the successful advocate a sense of order is the most valuable. The gift of so selecting and arranging facts and arguments that the exposition of the case shall be well proportioned and logical and its pattern harmonious cannot be over-estimated. Orderliness is itself persuasive. What the mind easily follows the mind is predisposed to favour". It may be retorted that the statistical, or other scientific, paper is not written primarily to persuade or gain favour. Perhaps not *primarily*, but in fact, of course, most scientific workers *do* write to be read and to convince the reader of the beauty, truth and wisdom of what they write. Otherwise why write at all? And with regard to writing, as statisticians, I think we should take particularly to heart Lord MacMillan's comment that "there are few higher intellectual pleasures than success in the task of expressing an argument or a conclusion in just precisely the right language, so that the thought is caught and poised exactly as we would have it. Clear thinking always means clear writing and clear writing is always good writing". While I cannot myself wholly accept that last belief, I am nevertheless wholly convinced that nowhere is clear writing more necessary than in the field of statistics. As one of our own Fellows (L. H. C. Tippett) has said, "it is more difficult to make inferences from data in the fields covered by statistics than in almost any other field". We should, therefore, be at pains not to make it still more difficult for ourselves and our readers by a lack of the orderly and clear presentation for which Lord MacMillan pleads in the lawyer.

I have in these remarks wandered far from the President's address. The tenuous thread between us has been Lord MacMillan and I hope he may on this occasion have filled the gap. However that may be, I would beg Lord Piercy to forgive my irrelevances and to accept my assurance, as I said at the outset, that they have been born of sheer necessity and not of any lack of appreciation of his address. I can at least, and at last, be relevant in saying how much pleasure I take in supporting this vote of thanks and at the same time in wishing Lord Piercy a most successful term of office as our President. I hope that he may enjoy that year as much as we shall under his guidance.

The PRESIDENT expressed his thanks for the kind way in which his Address has been received.

As a result of the ballot taken during the meeting the candidates named below were elected Fellows of the Society:

Roy Annable.
Clifford Bamfield.
Robert Reid Barclay.
Donnan Peter Baron.
Arthur Bolton.
P. B. Brahma.
Harry Stephen Brown.
Thomas William Brown.
John F. R. Casimir.
Alfred Charles Cole.
Lynette Grace Cooke.
Stanley Ernest Creighton.
Alexander Taylor Elder.
Norman Ferguson.
Peter Reginald Fisk.
Donald H. S. Forbes.
Oliver J. C. Francis.
Gerald Joseph Goodhardt.
C. H. Gravelle-Williams.
J. A. Gunton.
Leopold Haller.
W. Harris-Burland.
Bernard Hogley.
T. H. Hollingsworth.
C. F. Hunt.
W. W. W. Jackson.
Gwilym M. Jenkins.
Emile Kay.
KennethP. Leach.
William Russell Lewis.
Robert Knight Lochhead.
Alan Robert McDowall.
Thomas Ivor McGloughlin.
Joyce Mary May.
Alan Mercer.
Kenneth Baston Millner
Chakradhar Mishra.
Frederick Irving Musk.
Robert Tuckwood Nightingale.
John Wheatley Palmer.
B. B. Pawar.
Gerard Joseph Pollock.
David Pomeroy.
Olgierd Porebski.
Joan McCabe Potter.
Frank B. Rampersad.
Hilda Annette Robinson.
Wulf Rodoe.

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John Fraser Scott.
Theodore Schlesinger.
A. K. Sharan.
Donald Joseph Sharp.
Victor John Small.
Dennis A. R. Stevenson.
M. Swaminathan.
Gordon Thackray.
Arthur Roger Thatcher.
William Stanley Townson.
Arthur Turner.
Shirley Elizabeth Vincent.
Edward Weekley.
David M. G. Wishart.
Alan Wragg.
W. Wronski.

Corporate Representatives

Richard Bailey, *representing* P.E.P. (Political and Economic Planning)
Jack B. Bretscher, *representing* Kuwait Oil Co. Ltd.
R. F. Burch, *representing* Statistics and Intelligence Division, Board of Inland Revenue.
D. H. Newbury-Ecob, *representing* Vauxhall Motors Ltd.
N. S. E. Pugsley, *representing* Exeter City Library.
F. Chalmers Wright, *representing* Federation of British Industries.

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Current Population Problems

With Particular Reference to the United Nations World Population Conference

[A Discussion before the Royal Statistical Society, held on December 15th, 1954, the President, Lord Piercy, C.B.E., in the Chair)

Opened by B. Benjamin, E. Grebenik, W. P. D. Logan, Brinley Thomas, J. Hajnal, J. A. Fraser Roberts

Mr. B. Benjamin:

The Quality of Demographic Data.—It is an essential condition for the study of population growth that reliable statistics should be available of the structure of the existing population and of the quantity and quality of the three main elements—births, deaths and migration—which contribute to population changes. These statistics vary considerably in coverage and quality from country to country.

The estimates of total population published in the *Demographic Year Book* 1953 are graded first according to whether the base data are derived from (1) continuous population registers, (2) census enumerations since 1950, (3) census enumerations between 1945 and 1950, (4) earlier census enumerations, (5) non-censal counts or partial censuses, (6) conjectural estimates derived by other means than counting; and these grades are further qualified according to the reliability of the data and methods used for time adjustment from the base data. Among those with 1950 census bases or later, and adjusted by substantially accurate statistics of births, deaths and comprehensive records of migration, are the United States, Mexico, Japan, Italy, United Kingdom. Some countries improve on this high standard by having continuous population registers, e.g. Denmark, Finland, Norway, Sweden, Netherlands, while others fail only in having deficient migration statistics, e.g. Canada, Western Germany, Austria, Yugoslavia. At the other end of the scale are those with non-censal base data and deficient vital registration data, such as Indo-China, Iran, Syria and others, with a recent census but nevertheless deficient registration, e.g. Argentine, Brazil, Venezuela, India, Turkey and parts of Africa. The quality of statistics in U.S.S.R. and China cannot be properly assessed.

The United Nations have laid down Principles for a Vital Statistics System (U.N. Department of Economic Affairs, Statistical Office, Statistical Papers Series M, No. 19, New York, 1953) recommending coverage of live births, stillbirths, deaths, marriage and divorce. The availability of such statistics varies widely. In some areas registration is not compulsory for all the five events and in others it is compulsory only for part of the population (e.g. "Europeans" or "non-indigenous" population in certain African territories). In India and Pakistan there is no compulsory provision for registration on a national basis but only municipal or state ordinances, which do not cover the entire geographical area. The statistics are incomplete for much of Asia and parts of Latin America.

Countries which are able to produce birth rates specific for age of mother or by order of birth are not numerous, being mainly limited to the more advanced countries such as Canada, the United States, Japan, and those of Western Europe. Fertility rates by age and duration of marriage are obtainable for very few countries indeed; among these the United Kingdom is accepted as providing one of the most reliable bodies of data. There are many countries for which cause of death statistics are deficient.

With regard to census coverage, the Statistical Office of the United Nations furnished a paper to the World Population Conference indicating the availability of data from recent population censuses, including (*a*) a map of the world showing areas where a population census was taken during 1949–53 and (*b*) a table showing selected new data of different general or economic characteristics of the population available in the Statistical Office of the United Nations from censuses of population taken in 43 countries during 1950–53. Those censuses which have been held vary widely in the number of characteristics they have measured. All of Europe west of the U.S.S.R.

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has had a post-war enumeration. This is true also of the whole of the Western Hemisphere except for Peru, which took a census in 1940, Jamaica (last in 1943) and Uruguay (last in 1908). Many areas in Africa and most of the major countries in South East Asia and Oceania have had post-war enumerations. Most countries of the Middle East, the U.S.S.R. and Indonesia remain the major areas for which no post-war census has been reported. The following table (taken from a paper submitted to the Conference by Forrest E. Linder of the Statistical Office of U.N.) is of interest.

Number of Sovereign Countries taking a Population Census: Each 10-year Period from 1855 to 1954

Time periods	*Total*	*Africa*	*N. America*	*S. America*	*Asia and Oceania*	*Europe*
1855–64	24	0	4	2	1	17
1865–74	29	0	2	5	3	19
1875–84	37	1	5	4	6	21
1885–94	35	0	6	3	6	20
1895–1904	44	2	7	5	7	23
1905–14	42	2	7	4	6	23
1915–24	48	2	9	4	11	22
1925–34	49	2	8	2	10	27
1935–44	44	3	9	6	9	17
1945–54	65	2	12	8	15	28

The number of such national censuses has increased fairly regularly from 24 in the period 1855–64 to 65 in 1945–54—a figure which exceeds by one-third the highest previous figure for this 100-year period.

The prospects for improvement depend on the resources which can be made available. Where territory is inaccessible and illiteracy widespread, considerable manpower and technical equipment efficient registration systems. The growing need is being recognized partly from the stimulus provided by the persistent efforts on the part of the United Nations to collect statistics at an international level and partly because there are few countries which do not have population problems of insufficiency, surplus, or internal distribution. Much is being done by the United Nations to provide technical assistance to under-developed countries and to provide regional training schools for vital statisticians and associated personnel.

Apart from these problems of coverage, continuous effort is expended to increase the efficiency of existing statistical organizations and the reliability of the data they yield.

The collection of accurate demographic data is beset with manifold difficulties. It is not usually practicable to observe directly the events concerned and it is therefore necessary to rely on an informant who, through true lack of knowledge, or misunderstanding, or intention to mislead may give incomplete or incorrect information. Moreover the enquiry may not reach all those it is intended to reach either by failure of the authority or evasion by the public. It is therefore important, with so many possible sources of error, not only that every effort should be made to avoid or minimize errors but that in addition an endeavour should be made to assess the nature and extent of the residual error in the data.

It might be thought that the best method of making this assessment would be the total, or sample, replication of the original enquiry. This would not be a complete check owing to inherent error in the second enquiry and the change in circumstances in the interval between the two enquiries, and it is often an uneconomic procedure, if not impracticable on other grounds; but it has been undertaken on a sample basis with success, especially in the U.S.A., and the method is likely to be used more extensively in the future. Commonly the population census is considered to be the most accurate source and, where possible other sources are checked against it; but even the census is not without error and does not always provide the best yardstick against which to test other demographic statistics. Methods of testing some of the census statistics may however be devised.

Once the total number of population at a particular date has been determined, it should be possible to maintain a continuous record of the number by taking account of births, deaths and migration. In practice the statistics of births, deaths and migration may be so inaccurate as to introduce an accumulating error which progressively reduces the accuracy of the populations thus calculated. But whether or not this occurs, these populations will contain any error in the base population, and the determination of the base must therefore be of a census or census-like character.

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Only in very indirect ways can the completeness of cover of censuses be examined. The enumerated census population can be compared with an estimate for the same date, built up from the population enumerated at the previous census with the recorded births and deaths and estimated migrants. The migration statistics are undoubtedly the least accurate of these three components in most countries. The comparison is therefore primarily a test of the migration statistics, is often crude but sometimes sufficient.

A comparison of census populations of children or married women with birth and marriage registrations respectively of earlier years suitably adjusted for forces of decrement can be used, to check, on the one hand, the completeness of birth registrations and, on the other hand, census marital condition statements.

Checks on internal consistency may help to improve the quality of census data. For example, in most countries from the time that tabulations were first made by single years of age, it has been clear from mere inspection of the figures that there exists a preference for certain unit digits and a dislike for others. This error may be substantially reduced by graduating the tabulated data. A more serious form of error in age statement—if it exists—is the transfer of a substantial number of ages, not to a neighbouring preferred number, but to a wholly different part of the age range; this may be suspected from anomalies in the age structure. One method of examining such errors is to apply to the numbers enumerated at each age at one census, the losses and gains from mortality and migration that they are expected to have suffered in the intercensal period, and then to compare the estimated survivors with the numbers enumerated at the next census at appropriately older ages. Migration statistics are again a weakness. Sex ratios form another useful internal test. Family size distributions for different recorded durations of marriage may indicate errors in statements of age at marriage. Inconsistencies of birthplace and nationality, of occupation and industrial status, or of age and occupation are a few examples among other inconsistencies which may be tested.

Sometimes other bodies of data exist against which census or registration material may be compared. Census information on occupation may be compared with statistics derived from the administrative records of the appropriate labour authority allowing for the different concepts involved. Statistics of attendance at educational establishments maintained by the education authority may be used to check the answers to questions on this subject if included in the census. Similar checks can be made of housing data. More important still are the matching operations, e.g. of census schedules against birth certificates to check ages, of census schedules against death certificates to check not only ages but such characteristics as marital condition or occupation. Much excellent work is being done in this way to evaluate the current quality of demographic data. Here again the work of the United Nations in laying down international standards of accuracy has been a great stimulus to national enquiries.

A very important point to be borne in mind is that whenever tests of data are carried out these should be designed to discover not only the errors, but *why* they occurred; so that remedial action can be taken.

The general principles for securing reliable demographic data are : (1) Intensive efforts should be made to ask simple and unambiguous questions and to understand the manner in which those questioned may reply. Greater use of pre-census sampling enquiries is necessary. (2) The reliability of data may be regarded as proportional both (*a*) to the degree of legal compulsion applied, e.g. a deceased person's body cannot be disposed of unless a satisfactory death certificate is produced—this is an important factor in ensuring completeness and accuracy in death registration; and (*b*) to the impact of registration on day-to-day affairs (production of certificates for employment or insurance, etc.). (3) Wherever it is possible to do so without replication of questions (which would be intolerably wasteful) checks should be applied by deriving the same fact from different bodies of data, preferably by direct matching operations where diversity of concepts do not invalidate comparability. (4) Publicity should be given to sources of error in an effort progressively to reduce them. Honest reporting of errors rather than concealment for the sake of authority is the best policy. (5) Analysis of the data for publication should not be pressed beyond the limits justified by the ascertained degree of accuracy. The degree of refinement in classification should be allowed a respectable lag behind the standard of accuracy of certification. For example, it is no good trying to separate particular diseases if, in the absence of sufficient diagnostic resources, the separation is an enforced guess.

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One extremely important quality has been left until last in this short contribution, viz., speed in the production of data. Much effort and experimentation is still required to reduce the interval between collection and publication of the data to an absolute minimum. "Cold" statistics are sometimes worse than bad statistics, and there is no reason why "hot" statistics should not be good.* Bold sampling design and full exploitation of mechanical aids will, it is thought, achieve much in the future.

PROFESSOR E. GREBENIK:

High, Medium and Low Fertility Areas and their Problems.—It is well known that the world to-day may be roughly divided into three areas with different levels of fertility. Most of Central, Northern and Western Europe, Australia, New Zealand and North America form a group of countries with low fertility, where the number of births to-day is either just below or just above replacement level. Asia, Africa, the Caribbean islands and parts of Latin America, on the other hand, exhibit a very high fertility, and there is another group of countries which is in a process of transition from high to low fertility levels. Whilst demographers might disagree about the most appropriate allocation of individual countries to one or other of these groups, the existence of this division is widely recognized. At the Rome Conference the problems of high and low fertility areas were discussed at separate meetings, but no special place was given to societies which were in the transitional stage.

It is also generally accepted that fertility differences cannot be explained in biological terms but are due to differences in the extent to which conscious birth control (where this term is used in its widest and most inclusive sense) has spread through the population. In the low fertility areas it has become well-nigh universal and the small family system has become part of the established pattern of society. In the 'thirties there was considerable alarm at the lowness of fertility levels and it was feared that an actual decline in numbers—which would continue with increasing rapidity—was imminent in many Western countries. The preoccupation with this problem stimulated much research into the methods of measuring fertility, and more recent studies appear to show that there had been a tendency to exaggerate the probable rate of decline and that, in fact, completed family size has become stabilized at a level which is not far from replacement.

There was agreement in Rome that such a stabilization had in fact taken place in Western countries, but there was a marked absence of enthusiasm to assess the final significance of the "baby boom" of the late 'forties. Indeed, only the French demographers claimed that the size of families in their country had actually been rising, and their claims were not accepted in their entirety by their colleagues outside France. It was thought that the Western world had now reached a stage where some degree of equilibrium had been restored, and where population growth in the future was likely to be slow and unimportant in relation to the rate of growth in other areas of the world. It is noteworthy, however, that actual declines in population were no longer forecast by anyone.

Interest in low fertility areas was therefore centred less on global problems of population growth, but was rather directed towards more specialized topics, such as differential fertility and the impact of population policies on developments in fertility. A number of findings relating to fertility differences between groups within the same country were reported to the Conference. Different authors used different methods of analysis, their studies related to different periods of time and they defined their groups in different ways, e.g. by occupation, residence, religion or education. It is therefore not surprising that their detailed findings differed from one another. In some areas—the Netherlands, for example—fertility appeared to have become more homogeneous, in other countries there were no signs of greater homogeneity. It is not easy to see to what extent these different findings can be accounted for by the differences in method used, and it is clear that in the field of differential fertility research there is a great deal of scope for international co-operation and consultation, both between governmental agencies and between research workers who initiate and carry out enquiries.

From the immediate practical point of view, however, interest has shifted from the problems of the low fertility to those of the high fertility areas. This does not mean that there are no unsolved problems in the former field—far from it. Much further research is needed before we can hope fully to understand the impact of economic, psychological and social factors on fertility which is

* The 1951 one per cent. Sample Census of Great Britain was an example of what could be done even without electronic machines.

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largely planned, and before it will be possible to formulate population policies on a better basis than simple "trial and error". But the problems of high fertility areas are so much more acute that they attracted the bulk of the attention at Rome.

The most difficult problem in studying the fertility of these areas consists, of course, of the shortage of reliable data. There was considerable discussion of methodological problems in various sessions of the Conference, and the contributions that sampling enquiries could make to our knowledge of those areas were stressed. Enquiries by sample were proceeding in India, Indonesia, Japan, Puerto Rico and parts of Africa, but a great deal of the discussion which follows will be devoted to India and Japan, as it is in these two countries that research is at present being most vigorously pursued.

An important and interesting paper on Indian fertility trends was contributed by Dr. S. Chandrasekaran of the United Nations Secretariat. Whilst he stressed that the discussion of fertility trends was bound to be somewhat inconclusive in the absence of reliable statistics, the indications were that it was extremely high and might be rising in the near future. Chandrasekaran did not believe that the moderate degree of urbanization which had recently taken place had influenced the number of children born to marriages whose fertility had just been completed, although he admitted that current birth rates in some cities were lower than in the surrounding countryside. He considered some of the institutional checks on fertility which might be influenced by urbanization, such as the ban on the remarriage of widows, and the restriction of sexual relations at certain periods of marriage, and he pointed out that urbanization might well make some of these traditional checks less effective. He pointed out that the decline in mortality which would bring with it a reduction in the amount of widowhood might actually result in increasing fertility. He concluded that it was likely that in the near future India's fertility might increase rather than decline. "Both in urban and in rural areas," he wrote, "powerful forces tending to increase fertility will operate. The counter forces may be too weak, particularly in rural areas, to check this increase. However, no one can be sure of the future course of events. One factor of uncertainty is the possible effectiveness of national measures designed to satisfy the growing desire for family limitation in most sections of the Indian population."

The existence of a desire for family limitation became clear from the report of Professor Wahlund, who went to India as consultant to the Indian Family Planning Study conducted under the auspices of W.H.O. In a pilot study in a rural area in Mysore State in some 75 per cent. of the couples sampled did one or both partners wish to learn a method of family planning. But it became fairly clear in discussion that the rhythm method of birth control which was taught was not satisfactory as a method of controlling fertility. The Government of India are sponsoring various research projects which have as their aim the production of a reliable and acceptable method of contraception. But it was by no means certain whether it would be possible to translate the latent demand for family limitation into effective demand in the near future and it is doubtful whether increased industrialization and urbanization will, as some suggest, lead to a decrease in fertility *ipso facto*.

From India we turn to Japan. There the pressure of population was made more acute by the repatriation of an appreciable number of Japanese to the homeland after the end of the war. Japan, of course, differs from India in a number of important respects. It is more heavily industrialized, the population is more literate, and fertility among the Japanese has already been declining for some time. Nevertheless, the level of fertility is still sufficiently high, given the present age structure of the population, to imply a rate of growth in the population which is causing some alarm in official circles. The Japanese government have taken two main steps to meet this situation. They have made legal abortion on socio-medical grounds possible, and they have set up an Institute for the Study of Population Problems to undertake research and help in the formulation of policy. Considerable use appears to have been made of the facilities for legal abortion; a figure of 800,000 legal abortions in one year alone was mentioned in discussion. Interesting findings have also been reported from the Research Institute. A number of teams have been sent out to the rural and industrial areas of Japan in order to disseminate information about methods of contraception. According to the Japanese workers these teams were successful in considerably reducing birth rates which had previously been at a high level. In some fishing villages the pregnancy rate fell by one-third within three or four years. As in India considerable latent demand for birth control was shown to exist, but the Japanese appeared to be more confident than the Indians of their abiliy to translate the latent demand into effective demand.

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Japan and India have been cited as examples of two high fertility areas in which there is latent demand for family limitation. Mention ought perhaps also to be made of a report on the attitudes of Africans in Uganda submitted by Mr. J. E. Goldthorpe of Makerere College. He reported that in Uganda, where mortality is still at a relatively high level, there does not appear to be much demand for birth control information. Large familes are generally desired, and it is only among the very highly educated that the idea of the possibility of family limitation has taken root.

DR. W. P. D. LOGAN:

Mortality Trends.—There were two meetings of the Conference at which the subject for discussion was Mortality Trends, one referring specially to areas of higher death-rates and the other to areas of lower death-rates.

The first areas, those with higher death-rates,* comprise practically the whole of Asia and of Latin America, much of Africa, and certain countries of South-East Europe. The areas with lower mortality are mainly Western Europe and the English-speaking countries elsewhere, e.g. Australia, Canada, New Zealand and the United States.

I shall comment first upon the situation in the areas of higher mortality, leaning heavily and unashamedly upon the rapporteur's draft report. The death-rates are in general higher in Asia and Africa (the non-European parts) than in Latin America and South-Eastern Europe. In several countries in these areas there have been very large reductions in mortality in the past two decades, e.g. crude rate per 1,000:

	1935–39	1953
Ceylon	25	11
Malta	20	11
Chile	24	13

Infant mortality rates in many of the countries in the high mortality area run at levels of 150 per 1,000 births or even higher (contrast England and Wales, 27) and constitute some 20 per cent. of deaths at all ages, with deaths of children over the age of one contributing a further 20 per cent. A high proportion of infant deaths occur during the post-neonatal period (over 4 weeks) and are attributable to socio-environmental causes.

However infant mortality rates in some areas are declining rapidly. For instance Ceylon had a rate of 141 per 1,000 in 1946 and of 71 in 1953.

From the demographic viewpoint one of the great needs of the areas of high mortality is an effective system of vital registration. These areas contain two-thirds of the world's population, and if mortality is declining to any extent—and it certainly looks as though it is—continuous demographic studies of the areas are needed in order that the effects upon the world population situation can be properly assessed. Sampling may have an important rôle here, but it can only be as an adjunct to vital registration; it cannot replace it.

Malaria control has had a striking effect upon general and infant mortality rates in recent years in a number of countries such as Ceylon, Mauritius, and parts of Central America. Public health measures in general, improvements in sanitation and nutrition, and therapeutic and prophylactic advances have also been very effective in lowering mortality. In the Soviet Union a crude death-rate of 30 per 1,000 in 1913 gave place to a rate of 23 in 1927 and 9 in 1953; this change, it is said, was the result of a socio-economic policy that has brought about rising standards of living and has provided an extensive system of free medical care.

As to the future, there is every reason to believe that downward trends of mortality will continue. Public health measures will gather momentum, and will be reinforced *inter alia* by higher levels of living and by assistance from the Specialized Agencies of the United Nations.

The effects of lowered mortality rates upon the population growth of these areas, and the consequence of these population changes will vary from country to country. In already highly populated countries such as India and Japan lowered mortality may have an adverse effect upon national welfare; but in the countries of Latin America an increase in population resulting from lowered mortality may well be economically advantageous.

I turn now to discuss (with a little more first-hand knowledge) trends of mortality in the areas with lower death-rates, i.e. Western Europe and the English-speaking countries elsewhere.

* Areas which had a general rate of 20 per 1,000 or more during 1935–39.

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In some of these countries the crude death-rates are still falling, but in others, such as England and Wales, they are practically stationary, or even tending to rise, owing to the ageing of the population.

Generally there have been very great reductions at younger ages, e.g. under 45, but at older ages improvement has been much less, particularly among men. One of the points, in fact, that was made was that an increase in the expectation of life at birth during the next 20 years comparable with that of the past 20 years can only be achieved by a considerable reduction in mortality in late adult life. Dorn has calculated that even if no deaths occurred under the age of 40 the expectation of life at birth of white American males would increase only from 67 (as in 1950) to 71, and of white females from 72 to 76.

It is important therefore to look at what are now the main causes of death at adult ages and to consider what the chances are of their mortality being reduced. The prospects are not, at the moment, particularly bright. The principal causes at ages 45 and over are the cardiovascular diseases and cancer, followed in importance by bronchitis and other respiratory diseases. Deaths attributed to so-called coronary disease are still increasing rapidly, and apart from suspicions that diet, obesity and lack of physical exercise have something to do with causing the disease, no great progress is being made towards prevention or cure. As for cancer, while the incidence of some forms, e.g. oesophagus is apparently diminishing, that of other sites, notably lung, still shows continuing increase. Of cancer of the lung there are signs now, at any rate in England and Wales, that the tremendous increase we have seen in numbers of reported deaths may come to an end within the next twenty years, giving then an annual total for men of from 25,000 to 30,000 deaths. This is rather speculative, but certainly there are no signs that the mortality of this disease will diminish in the near future.

With tuberculosis the situation is very much more hopeful, and during the past five years there has been an enormous reduction in mortality, following the introduction of a number of highly effective chemotherapeutic substances.

There are some remarkable differences in levels of general mortality between countries even within the low mortality area, for instance between England and Wales and the United States, on the one hand, and Norway and the Netherlands on the other. The table below gives death-rates per 1,000 for 1950 and as well as showing low crude death-rates at all ages in the Netherlands and Norway it shows still greater differences at ages 60–64 (an age group which I have selected at random), particularly for men. I do not think it is widely realised that in this country and in the United States the death-rates of men at these ages are about twice as high as those of women—yet in Holland and Norway the men do not appear to have anything like this enormous disadvantage. Clearly there is a large field here for research; and since many of the degenerative and chronic diseases of adult life probably have their origins back in the earlier years, and may be either environmental or genetic or both, a better understanding of these problems requires, as Spiegelman pointed out in his paper to the Conference, not just death-rates but an adequate body of morbidity data to show how the incidence, prevalence and fatality of specific diseases varies from one country to another.

It was pointed out by Tabah and Sutter, from France, that the death-rate curve with age now tends to follow a simple exponential law, as suggested by Gompertz, because the constant introduced by Makeham to allow for deaths from infectious diseases is gradually disappearing. By dividing the death-rate into two components—an endogenous and an exogenous—an exponential formula can be worked out for the endogenous part. This latter is not invariable, but varies less,

Death-rates at All Ages and at Ages 60–64 *per* 1,000 *Population, by Sex*

	All Causes, 1950			
	All Ages		*Ages* 60–64	
	M.	*F.*	*M.*	*F.*
England and Wales .	12·3	11·0	28·3	15·8
United States . .	11·0	8·2	28·6	16·9
Netherlands . .	7·7	7·2	17·1	14·1
Norway . . .	9·2	9·0	16·4	12·6

Source: *Annual Epidemiological and Vital Statistics*, 1950. W.H.O.

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with environmental differences, than the exogenous component. This concept of exogenous and endogenous components of mortality is a development of earlier work on similar lines by Bourgeois Pichat on infant mortality; while I am, meantime, a bit doubtful of its practical applicability I find it a stimulatingly new way of looking at mortality curves, and I believe that we shall be hearing more about it in due course.

Professor BRINLEY THOMAS:

Migration.—Migration was discussed at the Conference from two broad points of view—*international* migration as a means of redistributing world population and *internal* migration as a factor in the development of highly industrialized countries and of countries engaged in industrializing themselves.

The scale of inter-continental migration in the period 1945–52 was set out by the Population Division of the United Nations as follows:

Intercontinental Migration, 1945–52

Emigration from Europe	4,452,000
Immigration into Europe	1,150,000
Non-European migration to non-European countries .	460,000
Other intercontinental migration	250,000

Of the estimated total of 4,452,000 European emigrants, nearly one-fourth came from the United Kingdom and one-sixth from Italy. About 1,200,000, or well over one-fourth, were refugees. The net emigration of 3,300,000 from Europe in the eight years, 1945–52, was the equivalent of three-fifths of one year's natural increase.

An analysis by country of destination is available for 3,774,000 of the emigrants from Europe, including persons resettled by the I.R.O. About 2·5 million went to the Americas, three-fifths of this total being absorbed by the United States and Canada, one-fifth by Argentina and one-tenth by Brazil and Venezuela. The countries of the British Commonwealth, including Canada, took about 1·5 million, about one-third of all European emigrants. From what is known of the 700,000 unrecorded emigrants, about 5 per cent. of them settled in Israel and most of the remainder went to the Americas.

Fragmentary figures for the continent of Asia for the post-war period, 1945–52, show an emigration of 500,000 persons, nearly half of whom were almost entirely Dutch residents of Indonesia who went to the Netherlands. Immigration into Asia is estimated at 675,000, of whom 400,000 settled in Israel. If we leave out Israel, the net emigration from Asia was under a quarter of a million, quite negligible in relation to the estimated population of Asia (excluding the U.S.S.R.) of over 1,320 million.

The prevailing view at the Conference was that international migration can do little to improve the present distribution of world population, since the countries which need immigration most have strong social and cultural reasons for restricting it, while countries which could easily absorb aliens into their social structure lack the economic conditions required for adequate expansion. It was also suggested, for example, that immigration has not contributed much to the post-war development of Canada.

This pessimistic attitude is no doubt justified when we reflect on the enormously difficult problems of the Far East: the emigration of 2,000,000 Chinese, which would amount to a quarter of the population of Australia, would be only 0·4 per cent. of the population of China. For every 100 Indians in the Republic of India there is only one resident abroad, and there is little prospect of future outflow. It is tempting to dismiss the intercontinental migration of 6,300,000 since 1945 as a drop in the ocean. However, one might have reached different conclusions if the role of international migration had been more precisely formulated. It was a great pity that the four sessions devoted to international and internal migration showed hardly any connection with the theme of "population in relation to capital formation, investment and employment" which was discussed two or three days later. Migration was treated too much as a demographic phenomenon divorced from its economic context.

Many speakers seemed to expect far more from migration than it can possibly achieve even under ideal circumstances. In the nineteenth century intercontinental transfers of

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population were an inherent condition of growth; but in the world as it is today this is no longer so. Nevertheless, migration still has an essential if relatively modest task to perform: there are parts of the world, particularly in the Western Hemisphere, where marginal shifts of labour, though minute in relation to the populations concerned, would be a powerful means of adjustment. Much would have been gained in the discussions at Rome if attention had been centred on particular cases where marginal transfers are practicable and potentially very beneficial, e.g. through a moderate revision of the McCarran Act in the United States or a change in official attitudes in certain Latin American countries. There was also a tendency to overlook the fact that a small rate of immigration can have a potent "multiplier" effect on the receiving economy.

One of the serious disadvantages of the divorce between discussions of migration and those of population growth was that little was heard of the interdependence of capital movements and migration. One of the most relevant factors since the war has been the marked change in the volume and direction of private foreign investment and the great part played by Government-sponsored capital flows. Unless this is taken fully into account, no discussion of migration as a means of redistributing world population can hope to yield helpful results. From the point of view of policy-making, it would have been instructive to examine whether migration in the future should be promoted through the agency of governmental or of private capital movements. While the Conference expected little from international migration, it did not consider thoroughly enough whether the necessary adjustments could be effected in ways which are alternative to transfers of population. A good deal of interesting material bearing on this was presented in a number of papers on individual countries, particularly on underdeveloped areas; and it would have been valuable if the suggesitve analysis presented by Dr. H. W. Singer in his paper, *Population and Economic Development*, had been taken up in the discussions on migration, his main point being that overpopulation is an asset rather than a liability from the point of view of a policy of industrialization.

The volume and character of recent internal migration in a variety of countries were analysed; but it was clear that much research remains to be done on the interaction between internal and international migration. This is particularly relevant when we consider the population problems of Western Europe; and many delegates would have rejoiced if Professor Ryabushkin of the Academy of Sciences, U.S.S.R., had elaborated his tantalizingly brief reference to the radical change that has taken place in "internal migration processes" in the U.S.S.R.

The Conference revealed the extent of the progress that has been made in the field of migration statistics, thanks to the work of the Population Division of the United Nations and the International Labour Office. Our attention was also drawn to the main gaps in our present knowledge in this field. Perhaps the most important lesson to be drawn from its deliberations is the need for a deeper economic analysis of population phenomena and a closer partnership between the statistician, sociologist and economist.

I should like to conclude with one or two general reflections. I was greatly impressed at Rome by the fundamental cleavage in method of thinking between the Russian and Western delegates. Two experts from Moscow took every opportunity of pinning on the Westerners the bogey of Malthusianism—the symptom of a decaying capitalist society. They declared that the Communists were the promoters of life, welcoming a high birth rate in the knowledge that their economic system will provide an increasing standard of living for the population however fast it grows. According to the Russians, western societies are obliged to curtail life to fit it within the capacity of their economies to provide sustenance. This was the major Soviet line of argument throughout the Conference: the performance was fascinating to watch but boring to listen to. One could not help deploring the fact that at a Conference organized by the United Nations there was no opportunity of any discussion of common intellectual problems with delegates from behind the Iron Curtain. The excuse was the language difficulty. The real trouble, however, is that words which mean one thing in the West convey quite a different meaning to the Russian mind. Unless scholars from the two opposing camps can discuss the concepts used in scientific argument and patiently arrive at agreed meanings, international conferences of this kind will not fulfil one of their main purposes.

The Conference might have paid more attention to the striking change which has come over the migration problem in Europe. I refer to the fact that Western Germany seems to be on the point of becoming a country of immigration. In recent years the Federal Republic, like Italy

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and Holland, has had a pool of surplus population from which oversea countries could absorb migrants. Several millions of refugees had been absorbed from Eastern Germany. At the present time there are signs that Western Germany is attracting labour from the rest of Europe; the other day negotiations were taking place with the Italian authorities for the immigration of Italian workers. This may be a temporary phase due to inflation; but there are grounds for thinking that the causes lie deeper. Nor can one ignore the economic consequences of the raising of 15 German divisions for the new army. Intra-continental migration may be developing a new pattern, and its bearing on the economic development of Western Europe needs to be re-examined.

Finally, I come to the migration statistics of the Far East. The records for Western countries have always been marred by serious defects, but there has been considerable improvement. Very little is known about migration in the underdeveloped countries of the Far East; it is most important that these gaps should be remedied as soon as possible.

Mr. J. HAJNAL:

Population Projections.—I shall not attempt a systematic summary of the papers and discussion on population projections at the Rome conference. Traditionally, one thinks mainly of forecasts for a whole country. In Rome, discussion ranged from projections for cities and small areas to a somewhat grandiose scheme, developed by the United Nations Population Division, for forecasts by a standard and almost mechanical method for every country in the world. The main thing which stands out in my mind is a sort of paradox. An ever-increasing amount of forecasting is being done all over the world amid a growing scepticism about the accuracy of forecasts.

The making of local forecasts (i.e. for cities and small regions) is obviously a thriving industry in many countries and I shall deal first with some of the developments reported in this field. Papers were presented about work in Finland, the Netherlands, Sweden and the United States. Local forecasts can be constructed by the methods which are used for whole countries; for example, by extrapolation of total numbers, extrapolation of rates of growth or by the "component" method (i.e. making explicit allowances for births, deaths and migration, usually by treating each age group separately). Local forecasts can also be made by taking an esixting forecast for the whole country and predicting the ratio of the population in the particular area to the total population.

The specific difficulty of local forecasts (whatever method is used) compared with national forecasts arises from migration. Because of the ease with which people may move about within a country the volume of internal movement is often considerably greater than movements across national boundaries, and migration is a very variable element in population change. There is nowadays an increasing tendency to tackle this problem directly. If one is dealing with a city with a fixed area which is already largely built up, one can try to estimate the "holding capacity" of that area. This is a method of limited applicability. More general methods are based on the idea that migration is largely determined by economic opportunity. To forecast the economic prospects of an area is a most ambitious undertaking and it was surprising to learn that efforts at economic prophecy are in this connection becoming an accepted procedure in many countries. The most common method is first to forecast employment in an area and then to pass from that to projections of total population.

Experiments in predicting local changes in employment have followed various paths, e.g. in Sweden they have included studies of the prospects of various industries in the area, made with the co-operation of managements, economic organizations and trade union leaders. Others have used more mechanical techniques of extrapolation for getting estimates of the future labour force in an area out of past trends in indices of employment or production in various industries, and so forth. A careful forecast involves a general analysis of the economic prospects of neighbouring areas and economic trends in the country as a whole. A detailed guide for making such an economic analysis in connection with population forecasts was published by the United States Department of Commerce in 1952. It may be worth mentioning a recent proposal for an elaborate scheme of input-output analysis to show how far methodological subtlety is advancing in this field.

A natural consequence of the economic approach is to stop dealing with a single area at a time and to build up instead general schemes for the construction of inter-related forecasts for all parts of a country. In the Netherlands, the need for this sort of work has led to the setting up of a Committee for Regional Population Projections. Its president, Mr. L. H. J. Angenot, describes its

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aim as "the study of the inter-relations between population growth in the various regions of the Netherlands, with the purpose of establishing a general basis for population projections of selected areas."

Local forecasts lend themselves especially to attempts to measure the success of different *methods* of forecasting by comparison of projections with actual populations. There are two ways of carrying out such tests. One is to take actual forecasts and confront them with the census counts. The second method is to construct hypothetical forecasts such as might have been constructed at some date in the past, using only materials available at that date. In the United States extensive tests of both types have been carried out using several sets of forecasts for the 48 states and hundreds of projections for individual cities. Dr. Jacob Siegel of the United States Census Bureau made a review of the tests and I quote a few sentences from his conclusion: "From the point of view of accuracy, the simpler methods appear to be just as accurate as the more complex ones; hence, a simple method may justifiably be used where time, resources and data are limited. Average errors are not always disturbingly large for short-term forecasts, but extremely large errors may appear in particular cases from the very start with any of the methods tested. The tests are consistent in showing an increase in the error with an increase in the length of the forecast period. Twenty-year forecasts generally have large errors and a sizeable proportion of errors exceeding 10 per cent."

This brings me to my second subject: Scepticism about the whole business of projections. Scepticism is, of course, mainly a consequence of the changed outlook on population brought about by the war and post-war events. Projections first aroused widespread attention when the prospect of population decline which they presented came as a shock to the public. The sudden spurt of population growth in the 1940's which belied these prophecies of doom came as something of a shock to demographers.

In its most extreme form the sceptical argument might run something like this: If simple methods produce as good results as the elaborate ones, why not go back to the good old days when such population forecasts as were needed were worked out, so to speak on the back of an envelope as occasion arose. Couldn't we do without demographers, that is without a special group of experts working out population forecasts by methods beyond the layman's grasp? The usefulness of other specialists in forecasting could be questioned on similiar grounds. The famous forecasts of American presidential election results made by public opinion polls were, it seems, no better even before the failure of 1948 than the predictions which would have been obtained by assuming before each election that the votes of the major parties would be divided in the same proportion as at the previous election.*

Even the sceptics would admit that it is unlikely that the volume of population forecasting will diminish. The demand for guesses at future population seems to have been growing. The increase in government planning and the growth of social insurance and allied services are perhaps the main reasons. At the same time, the statistical material available for the study of population and the techniques used for their analysis have become much more plentiful and complex. Increasingly they require specialists to handle them. Moreover, the need in modern times is often not for forecasts of total population but for projections of special classes, such as particular age groups, numbers of people with certain numbers of children, etc., and such projections generally necessitate the use of specialist techniques.

Most people would agree that there is a need for more projections produced by quick and simple methods, particularly estimates of the survivors among cohorts already born. Complicated techniques in this field also have some of the cumbersomeness of all complicated machinery. Elaborate sets of projections take a lot of time to prepare; so they are often a year or two behind the latest data when they are published, and they cannot very well be kept up to date.

Nevertheless, most people would agree that elaborate forecasts are occasionally worth undertaking. They often have value as instruments of study giving insight into population changes, even if their accuracy in prediction is poor. Many would go further than this. Some would say that there is reasonable hope that further research and experimentation may enable us to discover methods of forecasting which on average will be more accurate instruments of prediction than those we now have. Others, and this opinion is probably more widespread, would say that when decisions are to be made, it is sensible to bring to bear on them all the scientific apparatus at our disposal.

* See *The Pre-election Polls of* 1948. Report to the Committee on Analysis of Pre-election Polls and Forecasts. Bulletin 60, Social Science Research Council (New York, 1949).

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Perhaps we should look at such arguments in a wider context. Population projections are only one among many ways in which statistics and statistical forecasting have been used in the formation of economic and social policy. This application of statistics has expanded enormously in the last few decades and the reason certainly is not to be found in the great accuracy of forecasts. It is not surprising that the function and justification of statistical forecasting is being subjected to searching discussion.*

Perhaps we should recognise that the demand for forecasts is generated in part by motives only weakly related to their accuracy; in other words that even very inaccurate forecasts fulfil a need. The point has been put in its sharpest form by Professor Devons when he compares the use of statistical forecasting as a guide for policy to the function of the magician in some primitive societies. For example, if you want to go out hunting and do not know whether the best hunting is to the north or to the south, you consult a magician; and that after all is a sensible thing to do because the important thing is to get on with the hunting. It would be disastrous to get bogged down in arguing. Much the same need lies behind the demand sometimes faced by demographers "Give me some figures, any figures are better than none". What such people want, perhaps, is someone to make up their mind.

Dr. J. A. Fraser Roberts:

Intelligence and Fertility: Genetic Influences.—Two of the meetings at the World Population Conference were concerned with qualitative aspects of population trends. One dealt with differential fertility in respect of intelligence. The title chosen, namely "Methods of Research on Relations between Fertility and Intelligence", was intended to direct discussion to criticism of the experimental methods used in past surveys and to invite suggestions as to how improved surveys might be carried out in the future with the hope of securing less ambiguous results. There is in fact rather more than ambiguity; there is paradox. On the one hand, in all those countries where investigations have been carried out, every survey which is not based on selected samples shows a negative correlation between the test intelligence of children and the number of their brothers and sisters. The correlations are of the order of $-0{\cdot}2$ to $-0{\cdot}3$. On the other hand the available evidence does not show that a decline in average test intelligence is taking place. The most important direct test, the repeated Scottish Surveys of 1932 and 1947, showed that if anything a slight rise had taken place over this period of 15 years. A number of factors were mentioned which might harmonize the apparently conflicting findings. It seems very unlikely that any of them could alone be sufficient; it is more probable that many of them contribute in varying degrees.

Intelligence test procedures as measuring instruments for investigating nature-nurture problems leave much to be desired. This was conceded by all who spoke. A culture-free test is an illusion and there are possibilities of disturbing effects ranging to frank artefact. It may be that there is a simple and direct connexion between rising numbers of children in the family and a lowering of test score. There is some evidence of this, just as being bilingual can also be shown to depress test results. As long as there is a large environmental component in the determination of test score, it is always possible that the association between intelligence and fertility depends predominantly on this non-genetic fraction. It is true, to make the simplest calculation, that average test intelligence would be slightly higher than it is if all families were of equal size, but to the extent that the difference depends on non-genetic factors, the effect would not be cumulative as generations succeed each other.

There are other complicating factors. For example, for obvious reasons of convenience testing is nearly always carried out on children. It may be that some of the association with numbers of brothers and sisters refers not to the final mental level attained, but only to the level attained at the age of testing. In other words, part of the negative association may depend upon differences in growth curves. In the analogous field of stature, according to Morant there has been little if any change over a long period in adult stature in this country, but the age at which maximum stature is attained has been falling continuously. Another point about a sample of 11-year-old children is that while it may be an excellent sample of 11-year-old children it leads to a very peculiar sample of parents, who range in age over a full generation and more. Theoretically at least, given

* See, for example, A. D. Roy and C. F. Carter, *British Economic Statistics*, Cambridge, 1954, and Ely Devons, "Statistics as a basis for policy" *Lloyds Bank Review*, July 1954, pp. 30–43.

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a changing pattern of fertility, associated with intelligence level, it would be possible to have the observed negative correlation without any resultant change in mean intelligence. More generally, there are other theoretical models, such as Penrose's, which would reconcile the findings.

It is clear that the approach to the problem in the past was too naïve. Possibly, however, the reaction in opinion has been too extreme. From over-simplification and over-confidence prevailing opinion has swung to extreme scepticism, to doubts as to the possibility of drawing any deductions at all, and doubts as to whether future researches are likely to be much more informative than those of the past. If so, the discussion at this meeting should go some way in pointing to a commonsense middle view. It does seem possible to draw some deductions, though cautious ones, from the data we have. But above all the very difficulties themselves suggest experimental and biometrical methods for dealing with them. Much work is in progress on the effect of coaching, both specific and general, on the results of intelligence tests. So far from attempting to find unfamiliar items, it may be possible to ensure that all the subjects have the optimum amount of coaching prior to the test. Social and economic factors can be studied simultaneously. Already a beginning has been made, for example in the Scottish Survey. As stressed by Maxwell, it is significant that with a number of variables held constant, for example, occupation of father or number of persons per room, the negative association still persists and is not greatly diminished in amount. Several speakers mentioned the value of the simultaneous study of physical measurements, which should provide a simpler model, free from psychological complications. Here too a beginning has been made in the Scottish Survey. It was held that long-term studies over many years are not impossible. An approach to discovering direct motivation in determining family size was made in the Indianapolis studies. Studies on twins and on foster-children should be more valuable than ever. Taken slowly, with adequate planning and with the realization that advance must come bit by bit—that this is not a problem to be solved once and for all in any one study, however large—it does seem that the future should see increasing enlightenment in regard to what is after all a specific problem which is there for all to see; namely, that whatever the reasons and whatever the consequences there are associations between intelligence and fertility.

The other section dealing with qualitative aspects of population trends had as its title "The Relation of Population Changes to the Distribution of Genetic Factors". This was a background discussion, largely theoretical, ranging over a wide variety of topics. That population changes must result in changes in gene frequencies is clear, but the variables are numerous and their interactions complex. It is difficult to measure what is in fact happening, even in the simpler instances, but it is useful nevertheless to consider the principles which must underlie genetic change in human populations.

It was stressed that as mortality falls, as conditions of life improve, as nutrition becomes adequate, as infections are brought under control, so do genetic handicaps increase in relative importance, standing out as the cause of an increasing amount of the disability to be seen in civilized communities. Kemp estimates that at any given moment in the European or North American populations, 2 to 3 per cent. of people are severely incapacitated for genetic reasons. There seemed to be some hesitation about whether modern conditions of civilized life are upsetting equilibria, so that harmful mutations are likely to accumulate progressively; and in addition to natural mutation, there is artificial mutation, due to the increasing use of radiations in industry and medicine, quite apart from their use in war. Probably those who take the more traditional view in genetics would say yes; while those who incline to theories of polygenic control of most hereditary variation would be much more doubtful.

A very useful summary was contributed by Penrose, who dealt with genetic equilibria. The first and simplest kind is neutral equilibrium. This, with random mating, is the Hardy-Weinberg law. If no genotype has any advantage the chance fluctuations which can occur in relatively small populations remain permanent. Nor do departures from random mating affect gene frequencies, for example assortative mating or inbreeding. It is perhaps unlikely that true neutral equilibrium ever occurs, but it must be approximately true for many genes. This is shown by numerous calculations on blood-group genes. These calculations are based on the Hardy-Weinberg principle and it is always found that observed frequencies are in close agreement with expectation.

The next kind of equilibrium is stable equilibrium; if a disturbance occurs by chance, the original frequency tends to be re-established. This can come about with a dominant or sex-linked gene when mutation and elimination due to reduced Darwinian fitness balance each other.

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Again a number of human examples have been shown to conform. A more important type of stable equilibrium involves an advantage of the heterozygote over the two homozygotes. An example is provided by the recent discovery that the gene which in double dose leads to sickle-cell anaemia, usually fatal in early life, when in single dose confers some protection against malaria. This is probably why the sickling gene is very common in African populations. A very small advantage of the heterozygote is all that is needed—an advantage which as a rule will probably not be large enough to be measured.

Finally, there is unstable equilibrium, which may perhaps be the usual condition underlying gene frequencies. Nevertheless, though unstable, many such equilibria are likely to change very slowly.

One concrete proposal emerged. It was suggested that in areas where living conditions have advanced sufficiently there should be permanent, systematic medico-genetic registration, a recording or reporting system; this to be associated with the public health, hospital and social care systems. Instruction in human genetics in medical schools was called for. Once again the value of twin studies was stressed. It seems clear that, in the future, studies of population trends, of migration and of the mingling of populations, of the break-up of isolates, can by no means ignore the genetic changes that are probable or inevitable concomitants.

Mr. COLIN CLARK: I did not get at all the same impression of world trends of fertility as that which Professor Grebenik has given us in his paper, and I do not agree with his reference to the French Institute of Demography. We should pay some tribute to the achievements of the French statisticians who in recent years have been working on this problem. A few years ago, we thought that we had done a good job if we measured fertility with the age of the mother as the principal variant. We soon discovered that we had not. Since then statisticians in different countries have been working on the measurement of fertility, taking into account several other factors, including the age at marriage, the duration of the marriage, and the number of children already born. When you start boxing up your data in as many compartments as this, they soon become unmanageable. We have to thank firstly M. Bourgeois-Pichat, who brought about a great simplification in 1950 by his discovery that duration of marriage had a parabolic relationship with fertility. Although his results have since been qualified, they were an extremely important step forward. His formula for measuring fertility has been shown by his colleague M. Henry to have a bias. M. Henry measures fertility in the terms of the "probability of enlargement of a family of given size". His most recent results, which are published in the French journal *Population* this year, show that this "probability of enlargement" of families in France reached a low point about 1935. French reproductivity has recovered sharply and has now got back to the level at which it stood before 1914.

Equally striking is the trend in the United States, where there has certainly been a reversal of the downward trend of fertility. Whelpton has recently shown that it was the women who were born in the quinquennium 1905–09 who had the minimum fertility, and that those born in the quinquennium 1920–24 are exceeding their predecessors by as much as 0·4 children per family. A transformation of the downward trend of fertility into an upward trend has also been found in Canada, Australia, New Zealand, and in many European countries.

Social legislation, economic security, the greater equalitarianism of modern society have all been quoted as explanations of these tendencies. In most countries, including England, there has been a marked lowering of the age of marriage.

But if we are searching for underlying causes, we are bound also to bring in the factor of religion. This may be a subject which is distasteful to the present audience, but as scientists trying to estimate the importance of the various factors in the explanation of observed facts, we cannot leave it out. Not many people will go through the hardships of bringing up a large family unless they have some religious conviction behind them. In many countries, I think that the recent marked rise in reproductivity has been in some degree related to a revival of religious belief.

Mr. S. SINGH: It seemed to me that at the Rome Conference less emphasis was placed on migration problems, especially in so far as they affect Eastern countries, and more emphasis on the high reproductivity rates. It should be remembered that in Eastern countries there are relatively fewer opportunities for migration, with consequent lowering of living standards which are closely linked with reproductivity.

The following contributions were received in writing after the meeting:

Mr. P. R. COX: As a Fellow of the Society who was present at the World Population Conference I regret that I was unable to be present at the meeting.

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Other speakers will probably have made clear that the Rome Conference provided a gathering-ground for persons interested in population matters who could impart something to their fellows and at the same time learn from them. As a grand scale *conversazione* it was a considerable success, and the result should be a raising of the standard of demographic work all round. A scientific approach to population problems was generally evident and there was an invigorating return to reliance on practical investigation rather than abstract theory. It is interesting to note that subjects such as population mathematics and reproduction rates were hardly touched upon; instead, there were discussions of the various possible ways of collecting, classifying and analyzing basic fertility statistics.

A tremendous amount of paper-work was undertaken in preparation for the Conference, and when the results are gathered together the library of documents should be a valuable collection, not only for the new research work described in it, but also for its historical significance as a record of the opinions and interests of demographers in all countries in 1954. Among the pamphlets specially printed for distribution among the delegates one or two are worthy of mention even in the briefest of accounts; for instance, the history of past population congresses, presented by the Institut National d'Etudes Démographiques; the Summary Chapter giving a preview of Great Britain's Family Census of 1946; two P.E.P. reports; and a draft, for discussion, of a Multi-lingual Demographic Dictionary.

The papers and discussions themselves were classified into many compartments and no one person can hope to do justice to them all, especially in a short space. I should like to mention briefly two matters. First, population projections; on the whole, the Conference was critical. Its two meetings on this subject were intended to deal respectively with methods and results, but in fact there was in each of them a strong undercurrent of scepticism. Those who contributed to the meetings were concerned most to test the accuracy of past projections, to consider the circumstances in which new projections could be enlightening and to argue whether some recent work had been worth doing—for instance the lengthy paper by the Population Division of the United Nations Organization on the future numbers of people in all parts of the World. In this paper the figures given for the United Kingdom were certainly surprising; although supposedly based on medium assumptions they showed an expected rise of nearly ten millions in our population between 1950 and 1980—an increase much greater than that in even the most extreme of the projections made for the Royal Commission on Population.

The second subject to which I want to refer is the measurement of fertility. Leaving on one side the interesting but specialized problem arising in underdeveloped countries where census and registration data are not collected, the principal matter for discussion to-day is the large number of different ways of classifying birth and family statistics and the need to decide which of the available methods is the best in various circumstances. It was a good time for all those concerned to get together, but unfortunately it cannot be said that the position has become any simpler as an outcome of their deliberations. On the contrary, the number of possible methods of analysis seems to have become even larger, including processes that are ahead of available statistical information, even in the most advanced countries. Some good will have been done, however, if demographers have come to realize more clearly that for the moment the best course is to attack the problem on all fronts and not to concentrate on one sector at the expense of others.

The Conference was on the whole organized very successfully, although there were defects: meetings varied in effectiveness—there were too many of them—and the debates were not always very lively. These were, however, minor faults and the main thing is that the pervading spirit was one of honest enquiry and honest doubt. One of the outstanding memories is of the friendly attitude of the delegates, especially those from the British Dominions and Colonies and from the United States, and of the helpful exchanges with them that were made possible.

Mr. R. H. DAW: When studying mortality trends over the years it seems to have become conventional to look at the ratio of the death rates for successive periods of time. In this way statements are arrived at like that of Dr. Logan that the death rates show much less improvement at the older ages than at the younger ages. Nevertheless for many purposes, of which the study of population growth is one, a comparison of the *difference* between two death rates, rather than their ratio, is more appropriate. As an example consider the male death rates in England and Wales in 1926–30 compared with those in 1946–50. In the age-group 25–34 the death rate reduced by 48 per cent. while for ages 65–74 the reduction was only 12 per cent. But the reduction at the younger age-group represented less than 2 deaths per 1,000 living while at the older age-group it was over 6½ deaths per 1,000. Expressing this reduced mortality in terms of the deaths which would have been saved, or rather postponed, in the 1931 census male population of England and Wales, it represents some 5,400 males at ages 25–34 and 6,400 at ages 65–74. I, therefore,

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feel that any statement, without some qualification, that death rates have improved less at the older than the younger ages is unjustified and may at times be misleading.

In the table on p. 18 Dr. Logan gives the death rates for ages 60–64 and states that for this age-group the male death rate in this country is about twice as high as that for females. He does not mention that this age-group is the one for which the ratio of male to female death rates was a maximum. In fact for England and Wales in 1950 this ratio was 1·8 at ages 60–64 and decreased steadily with increasing age, being only 1·3 at ages 75–79.

So far as the older ages are concerned I have wondered whether it is really appropriate to compare male and female death rates for the same ages. If, for instance, the process of degeneration in women started at a later age or proceeded at a slower rate than in men, then a more meaningful comparison might be of the male death rate with the female rate for an age a few years older; in other words to attempt to base the comparison on equal ages measured on a scale of degenerative age rather than on calendar age. A lot of research would, of course, be needed to put this suggestion on a sound basis, but it is possible that it may go a little way towards explaining some of the anomalies mentioned by Dr. Logan.

Professor GREBENIK and Dr. LOGAN subsequently replied as follows:

Professor GREBENIK: In reply to Mr. Colin Clark I should like to say that I have the highest admiration for the researches carried out by the Institut National d'Etudes Démographiques and for the work of MM. Bourgeois-Pichat and Henry in particular, and I am sorry if I have given a contrary impression. In my contribution to the discussion I was merely trying to stress the point that a number of participants at the Rome Conference were not fully convinced that there had been a permanent increase in fertility in France, and they seemed to feel that it was premature at present to assess the significance of the boom in births during the late 'forties. It is possible that Mr. Clark may be proved right in his view by events, but I, personally, would like to suspend judgement for a little longer before accepting the recent increases as a "transformation of the downward trend in fertility".

Dr. LOGAN: Mr. Daw considers that to use the conventional death rates as I have done is unjustified and may at times be misleading. I do not think he is on very firm ground in this particular instance and I am sure no one has been misled. It is not difficult to envisage circumstances, in population analyses and elsewhere, where the use of other functions than the conventional death rate would be advantageous, but these circumstances did not arise in my paper.

Mr. Daw's mention of "degenerative age" has reminded me that there was some discussion at Rome of "physiological" as opposed to "calendar" age; and his point, I believe, amounts to this, that for certain purposes we ought to compare males and females not on the basis of numbers of calendar years of age lived, but on the basis of the proportion of total expected years of life already lived. (For example, we regard a dog as very old at 14 but a giant tortoise is still young at 40.) But, having made such an adjustment in our thinking about adult males and females, I am not clear where we are meant to go next. The concept does not seem to offer any approach to an understanding of why this difference in mortality between the sexes does in fact exist, and why it should differ between one country and another.

As a result of the ballot taken during the meeting the candidates named below were elected Fellows of the Society:

A. A Amirayan
R. L. Bishnoi.
Philip Walter Bradley.
A. G. T. Carter.
S. Y. Gaitonde.
V. J. Howell.
Audrey Y. Knight.
Edwin Mansfield.
Dennis T. Marshall.
Anne D. Outhwaite.
M. B. Priestley.
Sidney Scregg.

Corporate Representative:

R. M. Jacobs, representing The Shell Petroleum Co. Ltd.

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Measuring Unemployment*

By H. A. Turner.

CONTENTS

	PAGE
1. The Indices: and a Case in Point	28
2. Short-time—and Overtime	30
3. Under-employment	34
4. "Unemployment"	38
5. "Holidays"	42
6. Some Oddments	43
7. Summary and Conclusions	44
Appendix: Employment in Manufacturing Industry, 1951/52	49
Sources and References	49

1. *The Indices: and a Case in Point*

Modern economic policy is very much concerned to prevent unemployment. Considering this, it is curious that informed people should seem so sceptical of the latter's official measurement. We have, for instance, an *index* of unemployment, to which politicians and the public attach some importance, and in terms of which British employment policy is still (I suppose) formally defined.† Most commentators on economic trends, however, seem to rely on other indices—to some extent that of "employment", but particularly that of production.

But it would clearly be useful to know just why and to what extent the index of unemployment is inaccurate, and whether it is inevitably so. There are good reasons (some of which may appear from the following study) to think that our current employment and production statistics may also be misleading in the presence of a recession. While a satisfactory direct gauge of unemployment would serve to indicate both the latter's social effects and an unused economic capacity.

What follows is a kind of dull detective story. In the British textile recession of 1952, the writer tried to find out what happened to the workers most hardly affected—the operatives of the cotton industry. The main material for this enquiry was the current public statistics of employment and unemployment. In cotton, these are supplemented to a degree more than common: enquiry was also helped by the existence of one or two independent surveys. Nevertheless, it was only possible to construct a reasonable picture by applying some knowledge of the industry's working conditions and a great deal of inference to these sources, and by checking against the experience of many people practically concerned.

Much of the result will be, by the time of publication, mainly of historical interest—though parallel studies‡ implied that the structure of the cotton industry and the character of its demand give it a certain liability to such recessions as that of 1952. But the enquiry had some more general results. It suggested that mass unemployment might take, under contemporary circumstances, a form significantly different from that mainly experienced in the 'twenties and 'thirties. It provided a commentary on the use and limits of the major public labour statistics. And while indicating some deficiencies of the latter, it also suggested ways in which these might be partly obviated.

The cotton recession was only the extreme case of a general movement. And while certain features of the industry—like its large female employment—are not typical, that (as I hope will

* In this study, I have been much helped by the advice and comment of the Director of Statistics, Ministry of Labour, and Professor Ely Devons. Their assistance does not, of course, imply their agreement to all (or any) of its conclusions.

† In 1950, to an enquiry of the United Nations' Economic and Social Council, the government said it aimed to have not more than 3 per cent. of all "employees" in unemployment at the latter's seasonal peak—apparently an attempt to give the Beveridge target of "97 per cent. employment" a closer definition.

‡ The causes of the cotton slump were examined by the present writer in *The Slump in the Cotton Industry, 1952* (with Mr. Roland Smith) and *Unemployment in Textiles: a Note and some Conclusions.*

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become clear) does not rob these results of wider application. They may, therefore, be of some general interest.

* * * *

The central fount of published information on employment* is, of course, the Ministry of Labour's *Gazette*. Its monthly section "Employment, Unemployment, etc." includes an estimate of the total working population (including the unemployed); a brief analysis, by broad industrial groups, of the number actually in "civil employment" (which embraces employers and those working for themselves): and a more detailed (but not comprehensive) analysis, industry-by-industry, of the numbers actually working for employers in different trades. Its unemployment statistics include that here referred to as the "unemployment index" (which is the percentage of the estimated total of *all* employees registered as unemployed) together with several detailed analyses, of which the most relevant here are those of unemployment by industry and by region. These last analyses distinguish workers "Temporarily Stopped" from those "Wholly Unemployed".

The Ministry's statistics for "employees" (who are the overwhelming majority of the working population) are derived from National Insurance cards, which all people employed for four or more hours a week (including those exempt from contribution to the Scheme) must have. These cards are exchanged annually, but in quarterly batches. Each card has an industry classification and the batch returned in the second quarter is analysed by the Ministry. From this analysis, supported by a return from all employers of five or more workers of the numbers of cards they hold, the Ministry derives the annual table "The Employed Population", which represents the position at the end of each May.† This table again includes unemployed workers.

Unemployment is recorded by a "count" of people registered at Employment Exchanges on the second (or third) Monday in each month. From this and the estimate of "employees" the Ministry can reckon each year (presumably by subtraction) the number actually *employed* in each industry. This last estimate is then revised month by month, mainly in the light of employers' returns (supplied by all firms in manufacturing industry with more than 10 workers and by a smaller sample from distributive and "service" trades) of the changes in their payrolls over the previous month.‡ The same employers' returns are the source of the Ministry's monthly analysis of "labour turnover", and are used quarterly to secure a statement of short-time and overtime in manufacturing industry.

Here the "cotton industry" was taken to be represented by the two categories "Cotton Spinning, Doubling, etc." and "Cotton Weaving, etc." of the Ministry's analyses.§ Alternative data for *employment* are available from the Cotton Board, which makes a direct weekly census; the latter's statistics are also rather more detailed and comprehensive than the Ministry's. But the Board's and the Ministry's series differ very considerably—and to an extent which it seems difficult to account for by differences in industrial demarcation alone; moreover, secondary series which are superficially similar are apparently subjected to very different treatment.‖ For equally respectable and official organizations to compile and issue apparently conflicting information is very confusing,

* A general account of the available series is given in Mr. Ainsworth's paper *Labour Statistics in the United Kingdom*, while more detailed descriptions and revisions appear from time to time in the *Gazette*.

† The method of this estimate has now been described in a note to *The Employed Population, end-May* 1953.

‡ These are known as the "L Returns". Summaries of the returns from the North-West are supplied by the Ministry's Regional Office to Manchester University's Economic Research Section: these were the only important unpublished official data available to the writer.

§ A third category, "Rayon, Nylon, etc., Weaving and Silk", includes some who would be in the Cotton Board's jurisdiction, but they are entangled with the silk industry.

‖ For instance, the *Gazette* (February, 1952) figure for employment in "Spinning, Doubling, etc." at end-1951 was 186,700: the combined total of the Board's *Quarterly Statistical Review* (March, 1952) for "Spinning", "Waste Spinning" and "Doubling" at end-1951 was 162,790; only a small part of this difference is accounted by the Board's treating part-timers as halves. The Ministry's "labour turnover" rates square with the changes in its employment tables; the Board's figures for numbers "engaged" and "leaving" do not parallel its "numbers on the books". The Board of Trade's *Journal* reproduces Cotton Board figures of employment. Those of the Ministry of Labour, however, are issued in the *Monthly Digest* of the Central Statistical Office. But to cap this confusion, the C.S.O. describes all figures so derived as referring to "employees", which in the *Gazette*'s terminology includes also the wholly unemployed registered in each industrial category.

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and must involve employers in some redundant form-filling. Here, since the classificatory basis of the Cotton Board's "employment" series clearly differed from that of the Ministry's returns for unemployment and short-time, it was only possible to use the former as a supplementary source. While the structure of the cotton workers' unions makes it impossible to derive an unemployment index from their records.

This essay's method will be to trace the steps by which the writer tried to establish the extent of unemployment among the cotton operatives. This unemployment took several distinct forms, so each type will be assessed separately, considering also how far the cotton experience may be taken as representative. Incidental comment will be made upon various public statistics (by way of footnote if not in the text). But in conclusion, the textile experience will be used to evaluate the major indices of employment and unemployment, and a final suggestion will be made as to the measurement of these things.

For comparison, it is convenient to take the industry's peak post-war labour force as a starting point. In November, 1951, the number of "employees" in cotton could be reckoned* at just under 327,000, including† some fifteen or sixteen thousand clerks and other "staff".

2. *Short-time—and Overtime*

The recession developed with an impressive velocity. In November, 1951, less than ½ per cent. of cotton workers were registered as unemployed. By the "count" of May, 1952—when recorded unemployment in cotton reached its maximum—the registration equalled 27 per cent. of the peak labour force. But about this time production in the industry was down on 1951 levels by over one-third and its machine activity by some two-fifths: it was thus clear that the workers still recorded as "employed" were by no means *fully*-employed. And since the recorded *employment* of the trade had fallen by only 18 per cent. at the end of May,‡ it also seemed that many of them were registered as *un*employed.

Of the 87,600 cotton workers on the *unemployed* register at the May count, all but a few thousand were signed-on as "temporarily stopped". Workers will be so registered if they have a fair prospect of re-employment by their last firm within six weeks, and since the usual condition of unemployment benefit (that the recipient shall accept "reasonable alternative employment" if available) is not immediately applied to such people, their classification is usually agreed between the Labour Exchanges and their employers, and is reviewed again when the six weeks is up.

But the *employment* in any industry is arrived at by varying the figure from the Ministry's annual enquiry in *proportion* to the changes shown each month by the payrolls of reporting employers. The latter provide by far the greater part of manufacturing employment: the smaller concerns make no returns, but that is only likely to make the trend unrepresentative in trades—like the garment industry—where small establishments are both numerous and very sensitive to market fluctuations. The method may also slightly understate variations in actual employment because *nominal* payrolls *usually* exceed the latter;§ but that is unlikely to be important in the short term. The main problem the method raised here was the meaning of its resultant statistic.

Employers are instructed to include workers stood-off during the week in their payroll return; but it was apparently not certain that they interpreted this to cover people stood-off for longer periods or indefinitely. So that the employment figure would include some of the "temporarily stopped", but not necessarily *all* of them.‖ In fact, it seemed possible for a worker stood-off for an indefinite period not merely to be recorded as "temporarily stopped" *without* being reported

* Based on revised figures from the Ministry's annual review published in February 1952, since only these are comparable with the monthly employment and unemployment figures subsequently issued.

† Estimated from quarterly classified summaries of cotton returns made by N.W. Regional Office, Ministry of Labour for end-October, 1951.

‡ According to the contemporary monthly series. Revised figures for total *employees* at end-May, 1952 were issued in *The Employed Population 1948–52*, from which alternative *employment* figures can be derived. But the revision incorporated changes in classification, and is therefore not strictly comparable with the various series of employment changes, unemployment, short-time, etc., issued in 1951/52 itself.

§ See *Attendance and Absence in Industry* for effects of varying managerial practice in deleting names from the books.

‖ For one purpose—its monthly estimate of the total working population—the Ministry has, as from July, 1952, assumed *all* the "temporarily stopped" to be reported as "employed". Its annual enquiry, however, was less definite: "The figures relate to employees (including persons temporarily laid-off but still on employers' payrolls).

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as employed, but also to be counted—since there appears no mechanism for informing his first employer if he takes another job—on the payrolls of two industries.

In cotton, however, it seemed pretty certain that virtually all the "temporarily stopped" were included in the payroll returns.* There were few indefinite closures of mills by May. The preceding years of labour shortage disposed managements to try and hold their operatives by "spreading the work". Unemployment benefit is payable for a minimum "period of interruption of employment" of two days in the working week. Under such circumstances, the register of the "temporarily stopped" was less an index of unemployment in the sense of complete loss of work than one of partial *employment*—that is, of short-time.

Short-time was, indeed, by far the most common form of "involuntary idleness" in 1952. There is, however, some interest in a closer analysis. The recession followed a pattern reminiscent of the 'thirties in that clerical and other staff employees suffered hardly at all from unemployment—their payroll strength showing no significant change.† The 79,400 cotton workers registered as "temporarily stopped" at the May count could be assumed, for practical purposes, to consist of operatives only. However, another index of short-time is given by the Ministry's quarterly enquiry, which showed rather over 44 per cent. of operatives on the payrolls of reporting employers to be affected by it in the last pay-week of May.‡ This could be reckoned as equivalent to 115,500 operatives on short-time in the cotton trade as a whole.§ A comparison of these two totals is revealing.

The particular systems of short-time that a depressed trade adopts will be determined by several considerations, including those of technique and costs, and its normal arrangement of working hours. No authoritative guidance on the organization of short-time was issued in cotton, except for weavers—and this came only when the recession was well-advanced.‖ But certain general conditions disposed separate establishments to select one of three main arrangements.

The five-day week of 45 hours is standard in the industry. The cost of starting the day's work itself discouraged "short days" and a moderate adjustment of output was commonly made by stopping a full day in the week. If that proved insufficient mills could stop two days in the week; and after losing three days' work on this system operatives could, under the insurance regulations, draw unemployment benefit. Managements did not like closing for long if they could avoid it; but neither they nor their operatives thought it worth *opening* for two days in the week only, for which benefit could otherwise be *immediately* paid. The third possibility was thus to stop a week at a time.

Technical and trade factors biased the choice of the spinning and weaving sections between these three systems rather differently. And particular circumstances produced some minor variants. But for practical purposes all the operatives on short-time could be thought of as stopped one day in the week, two days in the week, or the whole week.

Now consider the difference between the two records of short-time for May. The count of the "temporarily stopped" was taken on May 12th, while the return of short-time was for May 19th–24th. The depression might have got a little worse over the interval: but not so much as to increase the number on short-time by 36,000. Nor was it likely that the number on short-time would fluctuate much between week-and-week. That happened in man made-fibre production, where establishments are few and large, but in cotton the separate arrangements of several hundred firms would average out: the count of unemployment, at least, showed a smooth curve from month-to-month. The monthly count, however, refers to one day (Monday), the

* Statistical evidence for this appeared later from the Ministry's annual enquiry. Deducting only the registered "wholly unemployed" from its total of cotton "employees" gave an "employment" close to that estimated from the monthly payroll returns.

† Judging by the Regional Summaries. See Colin Clark's *National Income and Outlay* for a calculation of unemployment rates among manual and non-manual workers in 1931.

‡ From *Short-time and Overtime in Manufacturing Industries.*

§ On total "employment" at end-May, deducting proportion of non-operative employees shown by Regional Summary at end-April.

‖ A Joint Committee of the Cotton Spinners' and Manufacturers' Association and the Amalgamated Weavers' Association recommended, in a circular dated May 14th, 1952, these systems of short-time working to their members: "(1) To play-off weavers for one or more days each week . . . (2) To play-off some or all the weavers for (say) a week or more . . . and then work for a week or more . . . (3) To adopt some form of rota system, such as 'pairing' some weavers . . . and working them turn about on the same loom complement." The last system seems to have been little used. It is only economic for electrically-powered mills, has administrative inconveniences, and was unpopular with the weavers.

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quarterly return of short-time to a whole week. But mills closing part of the week preferred (for obvious reasons) to stop on days next the weekend; and they usually do so on Mondays to avoid disturbing pay-day routines.*

The different periods to which these two records related was thus not an important cause of their discrepancy. Its major explanation was that many workers on short-time did not sign-on as unemployed, because they would get no benefit by doing so. Operatives stopped only one day in the week, for instance, were not likely to register.† However, it seemed that at least a quarter of the operatives were not eligible for unemployment benefit in any case, and irrespective of the number of working days they lost.

Before the slump rather over one-third of all cotton workers were married women. And another 6 per cent. were over "retiring age" for National Insurance purposes. The proportion of these workers who had exercised their option not to pay Insurance contributions was unknown, but one could make an estimate by assuming the national ratio to apply. Thus, in the country as a whole 45 per cent. of employed wives "contracted-out"; this would be equivalent to 15 per cent. of all cotton workers not insured against unemployment—a figure very close to that surmised by a contemporary P.E.P. survey of the local social insurance administration. Similarly a further 3 or 4 per cent. could be reckoned as ineligible because they were in receipt of pensions. And then there were the young people and other new entrants who had not yet paid the 26 continuous contributions required to qualify under the Scheme; from various sources these could be estimated at about 2 per cent. of all operatives.‡

A sizeable number of other workers was disallowed benefit for various reasons—interrupted contribution records, spare-time earnings over £1 a week§ (for instance, as a union collector or domestic help) and so on. The P.E.P. survey quoted local enquiries as establishing "that the proportion of disallowances was from 5 to 10 per cent." This reference included the "wholly unemployed" and extended to the summer months; the writer's inclination was not to put the proportion of disqualifications among operatives working short-time in May (when the Insurance administration was less stringent than it later became) above 5 per cent.

Most of the people quite cut off from benefit were not the sort who would have registered solely to get other jobs. The short-time arrangements were intended to dissuade them from leaving. Married women and old workers had often been persuaded to stay at (or come back to) particular mills in the time of labour shortage—and had anyway small chance of other work at this time. Very few workers applied for National Assistance—which might have required them to register. One need not sign as unemployed to be told of vacancies.

Some, of course, signed-on before they discovered their disqualification. But equally, some qualified contributors failed to register: many were only entitled to *reduced* benefits, the regulations and "case-law" of Insurance eligibility are (to say the least) bewildering,‖ and there was a widespread belief that Exchanges retained powers of "direction". Officials in the cotton districts put¶ the proportion of *all* registered unemployed who got neither benefit nor assistance at "well below 10

* The P.E.P. Survey *Unemployment and Social Security in Lancashire* reports an opinion that it was "more common for mills to be laid off Thursdays and Fridays". This was not the writer's information. Moreover, if the operatives stopped on Mondays were only those laid-off a full week, the May count of "temporarily stopped" alone would thus indicate a loss of nearly 3·6 million working hours from the week. But the week's total loss indicated by the short-time return for all systems was only just over 2·7 million hours. Most of those stopped *less* than a week, therefore, must also have been off on Monday.

† The regulations do permit a worker stood-off one day a week to claim benefit after a period, but this requires an alternation of working and lost time inconvenient to most firms, and is, I understand, also contingent upon the terms of particular collective agreements. The possibility did not seem widely known, in any case, while stopping one day was generally only an interim measure.

‡ The estimates in this paragraph were made from: the *One Per Cent. Sample Tables* of the 1951 Census, the *Report* of the Ministry of National Insurance and its leaflet N.I.12, the *Second Report of the Government Actuary*, the Ministry of Labour's annual statements *Age-Analysis of Employed Persons* (which strictly relates to all "employees") and *Young Persons Entering Employment*. All these estimates were derived from 1951 data, but their substantial validity for the time of the slump has since been confirmed by later material. A detailed examination of the changes in composition of the cotton "employed population" (with some comment on the annual *Age-Analysis*) was made in the writer's *Cotton's Labour Force*.

§ The difference between the implied definition of unemployment and that of employment (See p. 29) will be noted.

‖ No doubt the occurrence is infrequent, but it seems quite possible for eligibility for benefit to be determined by the random chance of the identifying letter of a claimant's insurance card.

¶ According to the P.E.P.

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per cent.", and this again covered both categories of unemployment—and included the "hard-core".

It thus seemed reasonable to reckon the proportion of operatives on short-time who would fail to register on account of ineligibility or disqualification from benefit at at least one-fifth. One could then estimate, for each section of the cotton industry, the distribution of operatives between the three main systems of short-time. The preceding argument implied that the May registration of the "temporarily stopped" represented 80 per cent. of all operatives stood-off the whole week or stopped for two days in it, while the rest (16,000) of the difference between that count and the short-time return consisted of workers stopped one day only. Since the short-time return indicates not only the proportion of operatives affected but the total number of hours they lost from the working week, the number stopped and hours lost under the other two systems could then be calculated by a simple simultaneous equation—with the result set out below:

TABLE 1

Short-Time in the Cotton Industry, a week of mid-May 1952

Operatives:	*On the Payrolls**	*Stopped One Day*	*Stopped Two Days*	*Stopped Full Week*	*Total on Short-time*
Cotton Spinning and Doubling .	148,000	13,000	45,000	24,500	82,500.
Cotton Weaving . . .	113,000	3,000	23,500	6,500	33,000
Cotton Industry . . .	261,000	16,000	68,500	31,000	115,500
Percentage	100·0	6·0	26·0	12·0	44·0
"Full-time Equivalent" (%) .	100·0	1·3	11·2	13·0	25·5

* By deducting proportion of "staff" employees in N.W. Region Summaries from *Gazette* "employment" figures.

These "full-time equivalents" merely express conveniently the loss of working hours—as a proportion of the labour of all operatives on the payrolls when working a full week.†

The loss of work from short-time was thus rather over a quarter of the hours the cotton labour force would normally have put in. Again, most of those stopped a full week were on some alternation of weeks on-and-off; others on the same system were working the week of the enquiry. So the number of operatives affected by short-time during May was over half of those on the payrolls.

The calculation shows the varying degrees of unemployment that "short-time" may embrace, and throws some light on the significance of the unemployment register (the count of "temporarily stopped" represented 30 per cent. of the operatives' payroll). Its more important point, however, was that it could be checked. The Cotton Board has returns from which the proportion of operatives stood-off for the whole week could be calculated;‡ this was almost identical with that shown by Table 1. The second check was given by the Ministry's six-monthly census of average earnings and hours. This census will not fully represent the loss of working hours (or wages) suffered by "employed" people in a recession because its result is calculated *only* on workers who attend for some part of the week. But a similar calculation could be made from Table 1 by excluding operatives stood-off the whole week. The average loss of working hours on this basis was again similar to that shown by the direct census. In confirming Table 1's calculation, these things also offered some confirmation of the various surmises (like those about the proportions of operatives who failed to register) made in arriving at it.

Judging from other North-Western trades affected by the recession, the systems of short-time worked in cotton were fairly typical of manufacturing industry with largish establishments. Indeed, in some respects the cotton arrangements were likely to yield a particularly high record of temporary unemployment. Thus, small garment-making concerns often merely shortened the working

† Here allowance has been made for the facts that the "strength" still included some 11,000 workers on *normal* part-time engagements (Cotton Board) and that a steady proportion of those on the payrolls are off sick, etc. Ministry of National Insurance monthly returns suggest the average percentage of "Insured Persons Absent from Work owing to Sickness or Industrial Injury" to be about four. Cotton Board returns normally show numbers working in the week about 7 per cent. below nominal payrolls, but the significance of this is uncertain.

‡ Weekly figures (supplied by Cotton Board) of "Numbers on the Books" and "Numbers Working". The former show the same proportionate movement as the Ministry's "employment" estimates.

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day; while in trades where Saturday morning was still normally worked, smaller establishments sometimes stopped work at Friday noon. Neither method of short-time made any mark on the unemployment registration—although over a period they might involve the same loss of work and wages as the system of stopping an occasional week.

A more important factor, however, was the prevalence in cotton of the system of stopping two days in the week. In industries like chemicals, with long or continuous processes, employers found it uneconomic to stop for periods of less than a week or so. And though the same proportion of the workers on short-time might *register* under this system, the former arrangement would produce a higher count of unemployment because of the *general* practice of stopping Mondays. For instance, a count in the week represented by Table 1 would have yielded two cotton workers stopped only two days for every one who lost the whole week—although (as Table 1's "full-time equivalents" show) the latter operative's loss of *work* exceeded the formers' combined. In effect, the system of counting the unemployed on Mondays inflated the cotton record.*

Of course, industries with a lower—and more typical—proportion of workers ineligible for unemployment benefit would record, for a given degree *and* arrangement of short-time, a higher unemployment registration than the cotton operatives. But, such industries are in fact not likely, if confronted with a similar fall in activity, to show such considerable short-time working. *Overtime* is restricted in the cotton trade, and for this its large female employment is a principal reason. But in industry generally, at least 4 per cent. of all work was, in 1951, done as overtime.† Reduction of this would clearly precede more elaborate methods of "work-spreading".

Now, when short-time is less intense a smaller *proportion* of the workers affected will register as unemployed. In May, 1952, and in manufacturing industry as a whole, only 37 per cent of operatives on short-time seem to have registered as "temporarily stopped"—compared with nearly 70 per cent. in cotton.‡ The proportion of workers *eligible* for unemployment benefit was higher in other industries; but fewer of them were losing enough time to *qualify*.

But loss of overtime, of course, affects neither the unemployment nor the *employment* index. All in all, the cotton experience did not seem to exaggerate the reticence of the two major labour statistics.

3. *Under-employment*

Short-time was not the only form of partial employment. Workers may, for instance, be kept on *whole*-time but with a reduced complement of machinery and at reduced wages. In past slumps, such "under-employment" was very common among cotton weavers.§ Indeed, the rules of at least one local weavers' organisation drew no distinction between this and other forms of unemployment,‖ paying benefit simply on "stopped looms". It did not seem to have been so general in 1952; it was frowned upon by both the weavers' union and their employers' association.¶ Nevertheless, it was a common opinion that under-employment existed in weaving, and the writer was himself given several instances. In spinning, no similar customary system of under-employment had emerged from the past. But no direct record of its effect was in any case kept in either main section of the cotton industry.

Since most cotton operatives are paid on piece-rates, reduced complements of machinery would almost certainly reduce earnings. But no evidence of under-employment was given by the Ministry of Labour's census for April, 1952. Average weekly earnings fell by more than 10 per

* A count on any other day, of course, would not produce a more comparable result. However, I understand the method of counting the unemployed on a specified day to be recommended by the International Conference of Labour Statisticians.

† See Appendix. "At least" because the Ministry's overtime returns cover only groups of workers classified by employers as both on "production" and as "significant". Its six-monthly "earnings and hours" return would suggest the proportion to have been larger.

‡ Calculated from the Ministry's statements of short-time and registered unemployment.

§ See E. M. Gray's analysis of the Weavers' Amalgamation census of 1935/1937 (in *The Weaver's Wage*).

‖ *Rules* of Manchester and Salford Weavers' Association, recently amalgamated with Ashton-under-Lyne.

¶ The joint circular of the C.S.M.A. and Weavers' Amalgamation (see p. 31, footnote) condemned under-employment in the strongest terms: "It is one of the things that got the industry a bad name in the pre-war depressions: it precludes the weaver from claiming Unemployment Benefit although not fully employed; it is prejudicial to the long-term efforts to develop systems of weaving which increase productivity." Under-employment was only permissible "as a last resort in very exceptional circumstances."

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cent. as compared with those returned in October, 1951, mainly because of short-time working—and the inclusion of operatives stood-off the whole week would probably have brought the average fall in weekly wages to about 20 per cent.* The average *hourly* earnings of cotton workers, however, actually showed a very slight increase (about 1 per cent.) over the same period. But this might have been due to several factors. "Key" workers were often kept on full-time, so that higher-paid operatives tended to lose fewer hours from short-time than the lower-paid. Pieceworkers on short-time but with *normal* machine complements tried to make up their earnings by increased hourly output (weavers in some sheds produced, the writer was told, as much in four days as formerly in five). Such things did not exclude a loss of hourly earnings to *other* workers from under-employment.

However, it did not seem impossible to estimate under-employment. The Cotton Board collects returns of "machines running," and further information from which it calculates every week the average hours run by each operating spindle and loom. By combining these two series one can reckon for any week the total hours put in by the industry's two fundamental tools.† A similar estimate can be made for their operators, by combining the Cotton Board's weekly return of "numbers working" with the Ministry's report of average hours worked.‡ One then has two indices (one of total machine-hours, another of total operative-hours) any divergence of which will generally indicate changes in the utilisation of labour. If, in the particular context of a recession, total machine-hours fell more than total operative-hours, that would show that workers were either minding fewer machines or being taken off their normal work—that is, that they were under-employed.§

This comparison raises two difficulties. Series of machine-hours are perhaps rather unfamiliar—indeed, are available for only a few trades. There is some interest, therefore, in a comparison with more usual indices of productive activity. In cotton, returns similar to those mainly used to compile the current Index of Industrial Production are available in the consumption of raw materials and the output of final products. Taken over the years immediately before the slump (and in periods since the recovery) these moved closely with the appropriate machine-hours series; but in the recession itself there were quite substantial divergences—up to 6 per cent. in some weeks. Generally, "production" ran higher than machine-activity, probably a combined result of lowered average quality‖ and of an "accelerator" effect—output at the point in the process from which "production" returns may be taken being maintained at a higher level than that of the machines concerned by the reduction of an intermediate working stock.¶ Raw material intake varied in *either* direction, because there these two effects did not coincide. The machine-hours series thus seemed the best index to be had of the work available in the cotton industry.

The second difficulty is, of course, that machine-hours can only be compared with operative-hours (the Ministry's "average hours" census being a six-monthly affair) for two weeks in each year. To get some gauge of this comparison's consistency, therefore, it was extended to dates before the "boom" weeks of 1951. In the preceding years the two indices moved closely together. Indeed, their minor divergences suggested them to offer quite an exact measurement. Over 1949–1951,

* Calculated from the data of Table 1.

† The Cotton Board itself publishes quarterly figures of "Machine Activity" on this basis.

‡ Here, of course, the exclusion of workers stood-off the whole week from the Ministry's statement is an asset, because the relevant Board returns do the same. The Board's "numbers working", however, includes staff employees, and allowance was made for this by deducting the proportion of such workers shown by the Ministry's Regional Summaries for cotton.

§ A survey by the Research Section of the Lancashire County Council's Planning Department in the Weaving town of Padiham (*Financial Times* report, January 23rd, 1953) apparently took a divergence between "machines running" and "numbers working" as sufficing to show under-employment. The returns, however, count as "running" or "working" any loom or operative working for *part* of the week. A divergence may thus arise from operatives working short-time "turnabout" on reduced plant, or from reduced shift-working: it does not necessarily imply under-employment in the sense used here.

‖ Cotton Board Returns show a marked fall in average fineness (or "count") of spun yarn in the recession; weavers reported lower earnings because of simplified or coarser cloths. It is some illustration of the possible effects of quality changes that in October/November, 1952, average output per employee was about 5 per cent. above 1951 levels, although other indications suggested the average productivity of labour to have deteriorated.

¶ This effect may be a quite automatic result of falling production, and is, of course, reversed when production is rising. Its working in textile industries was examined in some detail in *Unemployment in Textiles*.

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they showed the ratio of machine-hours to labour-hours as *falling* in spinning at rather over 1 per cent. each year, and *rising* in weaving by just under 1 per cent. annually. This would be consistent with the *general* effect of labour "dilution" in these years of rapid expansion having been offset, in the weaving section, by the "more looms per weaver" movement. More important, the result agreed almost exactly with an estimate of changes in average *productivity per head* made by other methods. Mr. K. S. Lomax has calculated* that about this time productivity (abstracting from quality changes†) was constant in spinning and increasing at just less than 2 per cent. annually in weaving. The *relative* movement here is almost exactly the same as that of labour utilization, which is shown by the writer's method; the difference in each *section* would be accounted if technical improvement over this period had the effect of increasing the average operative's output by about 1 per cent. annually in each branch.

So much for the preliminaries. Assuming the operatives to have been fully-employed in April, 1951, the proportion by which the index of *their* total working hours subsequently exceeded that for the machines indicates the degree of their under-employment at each later date.‡ As follows:

TABLE 2.

Under-employment in the Cotton Industry, 1951–53

	Spinning			*Weaving*		
	1	2	3	4	5	6
Week Ending	*Total Operative-hours*	*Total Machine-hours*	*Under-employment %*	*Total Operative-hours*	*Total Machine-hours*	*Under-employment %*
April 28th, 1951 . .	100·0	100·0	Nil	100·0	100·0	Nil.
October 27th, 1951 . .	101·0	100·4	0·5	102·3	101·1	1·0
April 26th, 1952 . .	62·5	54·8	12·3	80·9	76·7	5·2
October 25th, 1952 . .	77·9	70·4	10·0	82·4	77·7	5·2
April 25th, 1953 . .	85·6	82·8	3·3	88·7	86·5	2·4

These percentages are, of course, "full-time equivalents". That is to say (for instance) that in April, 1952, the amount of normal work available in spinning could have been done with a further reduction of operatives' hours equal to one-eighth of the total actually worked.

What was most surprising here, in view of the historical association of under-employment with weaving, was its pronounced extension to the spinning trade. But a similar redoubled impact on the section further from the consumer was shown by every other index of the 1952 recession: and Table 2's results also conformed closely to what was known of the slump's detailed development and timing as between the two sections.§ It seemed, however, that under-employment in spinning took the form of keeping operatives on makeshift work—cleaning machinery, painting and whitewashing and the like—rather than reduction of machine complements. And for this there was some slight statistical evidence. It is clearly easier to "make work" for men than for women. In spinning, average hours put in by men fell rather less than those of women. In weaving, where the traditional system of under-employment applies to operatives of whom most are women, the reverse was true.‖

These estimates of under-employment remained, however—as "full-time equivalents"—abstractions. They could be added to the similar estimates of Table 1—so as to say that the combined effect of short-time and under-employment among operatives still on the pay-rolls in April/May, 1952, was *as if* one-third of them had been quite idle. But it was not also possible to reckon how *many* workers were affected by under-employment. Thus its "full-time equivalent" in weaving was equal, in April, 1952, to the normal labour of 5,000 workers. Before the War, a weaver's

* In *Recent Productivity Changes in the British Cotton Industry*.

† Average "counts" of yarn declined significantly between 1949 and 1951.

‡ Differences in coverage between the separate returns drawn upon mean, of course, that each can only be taken to represent a very considerable *sample* of the industry's machines and workers, so that only the proportionate movements of the two resulting series of total hours is significant.

§ See graph IV of *Unemployment in Textiles*.

‖ According to the Ministry's census, in cotton-spinning the fall between October, 1951, and April, 1952, was 13·5 per cent. for males and 15·6 per cent. for females; in cotton weaving, 7·8 per cent. and 6·7 per cent. respectively.

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normal complement of looms was four, and under-employment usually meant a reduction to two. Had these arrangements held in 1952, and had only weavers been affected, 10,000 of them would have been under-employed. But loom complements have increased on the average and are generally more diverse, while under-employment in the weaving section certainly extended in 1952 to other operatives than the weavers proper; the absence of any conventional system of under-employ-employment in spinning made a reckoning there even more difficult." From some knowledge of technical and trade circumstances, one could guess the total number of cotton operatives affected to have been about fifty or sixty thousand, of whom perhaps a third were *also* on short time; but the method is too speculative to be worth detailing here.

A major reason for measuring unemployment is that it makes people less able to earn their own living. The *time* lost through short-time thus represented an almost proportionate loss of pay.* Not so the *work* lost from under-employment. Again, the latter's effect could only be guessed. Among the cotton industry's many occupations, it varied with their diverse circumstances and notoriously complex wage-systems. Time-workers would lose nothing of their agreed wage from under-employment; but this equally made them particularly expensive for a management to keep about. "Straight" pieceworkers would have lost pay in direct ratio to the effect of under-employment on their output; but all systems of payment-by-results in cotton now include some constant element. It would probably not be unfair to describe the average effect of the relevant collective agreements as being that where work was lost through under-employment, about 20 per cent. of the wage usually paid for it would also be lost.† Some temporary local arrangements, in effect, lowered this "fall-back" somewhat.‡ And one does not know how strictly the complicated clauses of the general agreements were observed: but no open and major breaches of them were reported.

Assuming, then, that the collective agreements broadly held, one could reckon the wages lost from under-employment at about one-fifth of its "full-time equivalent". This would represent between one and one-and-a-half per cent. of the industry's "boom" wage-bill. Compared with that from short-time, this loss was small. But one might also compare it with the probable loss of wages from reduced overtime—perhaps a more widely recognized effect of bad trade. This could be estimated in much the same way—by taking the average overtime rate of collective agreements together with the "full-time equivalents" of overtime implied by the Ministry of Labour's returns. The decline in overtime between September, 1951, and May, 1952, involved a loss of only some 0·4 per cent. on the "boom" wage-bill.§

The "flat-rate payments", "fall-backs", "standing-wages" and similar constant elements in their contemporary wage-systems not only cushioned the cotton operatives against the full effect of under-employment. They also penalized employers who resorted to it, by increasing their labour costs per unit of output. This generally compelled "involuntary idleness" to take a more open form.|| But short-time involves uneconomic dislocations of factory routine, and is inferior as a device to hold labour. Under-employed workers will be given a low priority by Employment Exchanges as against those more openly unemployed. Full-time attendance reduces their chance to seek other work, and if they resign to do so they forfeit unemployment benefit. Under-employment even has some positive advantages to firms. A reserve of labour on the spot is useful: and reduced machinery-complements per worker may yield a higher output per *machine*, and thus smaller fixed costs per unit of output. If their workers' earnings were related to output alone, employers could clearly realize these advantages to the full. However, a wide gap (like that usual in engineering) between normal piecework earnings and an agreed basic wage has a similar effect, and a persisting surplus of labour is likely to undermine even such high "floors" as those implicit

* The major "guaranteed week" agreements in any case have an escape clause to cover a "stoppage . . . for adjusting output to trade circumstances."

† Current spinning agreements commonly provide for piecework earnings 20 per cent. above a time rate. Where the weaving guaranteed wage agreement applied the average "fall-back" would probably not be less; where it did not, generally lower and sometimes very much so.

‡ In one district spinning and doubling mills guaranteed 75 per cent. of normal earnings to workers in full attendance.

§ Where overtime is covered by agreements, rates vary from one-and-a-quarter to one-and-a-half of standard for the first hours of overtime. The rest of the calculation is from the *Gazette's* overtime and employment series.

|| In terms of numbers affected and pay these rough estimates suggested under-employment to have been very much less severe than that shown by the weavers' censuses of 1935/36 (see *The Weaver's Wage*). Under-employed operatives in the 'thirties often earned less than the standard unemployment benefit.

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in major cotton agreements. Short-time is an obvious first expedient; but if recession endures under-employment may supplant it in importance.

In this light, consider the situation in autumn 1952. By the end of August, both the number of operatives on short-time and the total loss of working-hours from it were down to some two-thirds of the May figures; a further decline was recorded by the Ministry's November enquiry. But the volume of under-employment was, apparently (see Table 2) much the same as in spring. If this change in the relative incidence of the two forms of partial employment were due to a relaxation of the wage-barriers to under-employment, the latter's depressing effect on pay would clearly have increased. There was, however, an alternative explanation. Recovery had begun, and mills which had hitherto held their workers by short-time might have been driven to seek a firmer tie. If (as Table 2 implies) some under-employment persisted into 1953, hoarding of labour against potential competitors was, by then, certainly becoming its dominant aspect. Since under this incentive mills would have to offer wages nearer normal earnings, the effect of under-employment on pay would decline. The writer's impression was that *both* depressive and amelioriating trends were in fact at work in late 1952, their primacy varying between districts and sections. Under such circumstances only a census could establish whether underemployment played more of Jekyll than of Hyde.

Summarily, then, here was a loss of work and pay which was not distinguished by the usual meters of unemployment. Under-employment was perhaps not very serious in cotton. But its effect compared with at least that *registered* by, for instance, the number of "wholly unemployed". It might be greater, moreover, in industries with different wage-systems, and in any more lasting recession.

4. "*Unemployment*"

There can have been few cotton operatives who had not suffered from some partial employment by the summer of 1952. Yet unemployment in its traditional sense—of workers without jobs—appeared negligible. In May the register of "wholly unemployed" represented less than 3 per cent. of the cotton labour force of November, 1951—an increase of only 7,000 since that date. But in the intervening six months the estimated number of operatives on employers' payrolls* fell by nearly 50,000. What happened to the workers who disappeared from both payrolls and unemployment register?

Here the evidence was at first sight contradictory. Trade and government officials all spoke of these workers as having "left the industry"—by clear implication, for other employment. The formula's adoption was perhaps not always quite disinterested; the masters' associations were much disturbed by demands that the state provide alternative work in the cotton districts. And even the unions—while supporting these demands—were apparently not too anxious to emphasize the labour surplus lest that prejudice their bargaining power.† Nevertheless, the description seemed reasonable. No direct record is kept of transfers of workers between occupations. But the anxiety of many mill managements to hold their labour was evident. And the loss of younger operatives was so sharp as to suggest the fall in cotton payrolls to be mainly due to the unwillingness of the more mobile workers to tolerate reduced earnings and insecurity.‡

On the other hand, the general employment situation showed no sign of such an abundance of alternative jobs as would readily have absorbed over 40,000 workers from cotton. Nationally, the estimated total§ of people in "civil employment" fell, tracing it month by month,‖ 200,000 between November, 1951, and May, 1952. And for industrial workers the situation was even more adverse than this statistic indicates; the fall in manufacturing employment alone exceeded that figure

* From the Ministry's monthly employment series. "Operatives" for reasons already given (p. 31).

† The unions based their wage-claim of late 1952 partly on the argument that 46,000 operatives had been "caused . . . to take up other employment" (Industrial Disputes Tribunal, *Award* of January 23rd, 1953). This seems to have been simply the fall in the Cotton Board's "numbers on mill books".

‡ The records of the Operative Spinners' Amalgamation (the only major union to make a seniority distinction) showed a heavy fall only in its younger membership.

§ These estimates include self-employed people (very much an estimate) and certain employments (like agriculture) from which the Ministry of Labour has also no direct returns or only returns (as from distributive trades) with a much smaller coverage than those from manufacturing industry. The latter, however, determined the major trend, which was so strong as to be unquestionable.

‖ Monthly changes taken here rather than direct totals to avoid the effect of occasional revisions. For the same reason, the Ministry's revised *annual* estimate for end-May 1952 is again ignored.

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and some part of the offsetting increases in employment (like those in agriculture and "services") were seasonal.

Next, it was clear that the cotton operative's chance of another job was much less than that of workers in other districts. Comparing, for each textile trade, the fall in payrolls with the increase of its registered "wholly unemployed", the recorded residue of final unemployment was substantially higher in cotton. And while no information on employment changes was published for the cotton towns themselves, one could estimate that in the North-West Region as a whole the number of jobs available fell (seasonal changes apart) by about 100,000 in these six months of the cotton recession.* The changing balance of demand and supply for Lancashire labour was partly illustrated by the records of Exchanges:†

	Vacancies Notified at N.W. Exchanges	*"Wholly Unemployed" on N.W. Register*	*Ratio, Vacant Jobs to "Available" Workers*
May, 1951	70,000	30,750	23 to 10
October/November, 1951 . . .	56,000	36,000	16 to 10
May, 1952	33,000	59,500	6 to 10

By contrast with these estimated falls in employment (of 200,000 nationally and 100,000 in the North-West) the national register of the "wholly unemployed" increased, in the six months to May, 1952, by only 73,000 (or only 37,000 if the June count be thought more relevant) and that for the North-West by only 23,000. The differences were certainly not likely to be due to any sudden fall in the number of people of working age. That there was some substantial unrecorded loss of jobs was thus clear.

One reason why much of this loss made no mark on the *cotton* unemployment registers was that married women were there most affected. Women suffered most from the recession in general. They predominated in the trades where employment was falling; but the industries where employment increased gave work mainly to men—the notable expansions in the North-West, for instance, being of collieries and engineering. The number of women registered as "wholly unemployed" in the Region increased, but by no means as much as women's employment fell. It was perhaps also significant that as the registers of final unemployment rose in the Region the number of long-term unemployed among women trebled, while that among men barely changed.‡ There was no information on the proportion of married women§ among the "wholly unemployed", but their chance of other jobs was clearly less than that of single girls.

Married women had played a special part in the post-war expansion of the cotton industry. Even in the "boom" year of 1951 the entry of juveniles‖ was insufficient—at just under 8,000—to replace the wastage of labour from death and retirement (which could be estimated¶ at about 12,000 operatives). In 1950/51 male employment actually seems to have fallen slightly—that of women to have increased about 3 per cent.ø This increase appears to have been largely of married women,** most of whom were probably returning to work after a period of domesticity; they were often engaged part-time only.

In general it seems that for every ten women who leave work after marriage, another seven married women have, in recent years, returned to employment.*** In Lancashire, the cotton industry had become an important outlet for such women as the latter. It could be reckoned (by

* Estimated (a) from N.W. Regional Summaries; (b) by applying percentage changes in employment in each industry shown by the *Gazette* to regional distribution of *Census*, 1951, *One Per Cent. Sample Tables.*

† From the *Gazette's* monthly series *Numbers Unemployed: Regional Analysis* and *Placing Work of Employment Exchanges.* The proportion of vacant jobs notified to Exchanges in May, 1952, was probably increased by the Notification Order of that year.

‡ See six-monthly analyses *Duration of Unemployment and Age of Unemployed.* "Perhaps" because the numbers involved are not big enough to be too definite.

§ The *Gazette* gives a monthly total, but this combines both official categories of unemployment and has no regional or industrial subdivision.

‖ Figures given by Ministry of Labour.

¶ From approximate national averages derived from *Age Analysis of Employed Persons* and adjusted for age and sex distribution in cotton.

ø According to *The Employed Population* 1950–1951.

** Data from Ministry's sample of Insurance cards, as supplied to Cotton Board.

*** Estimated from comparison of annual *Age Analysis of Employed Persons.*

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deduction from "wastage" and "entry" estimates) that some 3,000 of them would normally have taken up work in the industry over the six months to May 1952. These the slump simply deprived of opportunity, and they were not likely to register as unemployed. An important effect of the recession was thus to frustrate the re-employment of such people rather than to deprive *existing* employees of jobs.

The immobility of married women and their small chance of other work made them, in any case, the only operatives that managements felt they could safely dispense with. Women on part-time engagements were particularly liable to dismissal to conserve such work as there was for full-time employees. The number of married women on the trade's payrolls probably fell by about 17,000, of which some 2,000 was due to a failure to replace married women—mostly full-timers—withdrawing from work. But the number of married female operatives who registered as "wholly unemployed" could not have been much more than 3,000—half the total women's register for cotton. Some 9,000 part-time engagements were cancelled, and not many of those affected were likely to be Insurance contributors or to have got other work. Perhaps two or three thousand former full-time workers were in the same position. All told, one could make a very reasonable guess that 10,000 working wives lost their jobs without registering.

But this still left some 30,000 of the decline in cotton payrolls unaccounted for. So the apparent contradiction between the view of officials and the statistical evidence remained. Its second explanation was that much of the unemployment caused by the cotton slump was dispersed over other occupations.

Young men and single women took jobs in the Region's few expanding trades—but even if all of the additional work there had gone to people leaving the cotton industry (an impossibility, if only because many of these new jobs were remote from the cotton districts) it could not have absorbed so much labour.* There was undoubtedly some displacement of workers in other industries. There it was not necessary for employers to *discharge* existing employees to make room for ex-cotton operatives. War and post-war labour shortage had drawn into employment many who would not previously have been considered—by themselves or employers—as available for it. On the average, about one-third of industrial jobs are vacated each year,† and "labour turnover" is probably highest just among these "marginal" workers. Though pensioners may also have been affected to some extent, it was again, in all probability, married women—who are most liable to interruptions of employment—who were specially concerned. "Frustrated re-employment", indeed, was probably much more important outside the cotton trade than in the industry itself. But such people were again less likely to register as unemployed when their supply of jobs dried up.

Some of this displacement, incidentally, was caused by people who were not cotton workers when the slump started, but would otherwise have entered the trade. From the spring, 1952, batch of school-leavers, recruitment of boys to cotton fell to one-third, and that of girls to one-half, of the 1951 entry.‡ One could estimate§ that about a thousand young men, who had been called up from the trade, were due to return from National Service between November, 1951, and May, 1952; these had the best choice of other work, and many preferred not to take "reinstatement" in cotton.

A third factor in cotton's low registration of "wholly unemployed" was that quite a few operatives, having first got jobs in other trades, lost them again as recession spread or because the work was only seasonal. And such people, if registered as unemployed, are "counted" under the trade in which they last worked, not under that to which they may consider themselves to belong.

The upshot of all these estimates and guesses may be summarised as follows: taking the number of cotton operatives who "left the industry" up to the end of May, 1952, as 50,000 (a simplification,‖ but not a very excessive one), some 20,000 were still out-of-work at that date. And of these only 7,000 were registered in cotton; about half were unregistered married women and two or

* Employment in N.W. collieries rose by 3,500 in this time. K. S. Lomax's *Lancashire Survey* estimated the increase in engineering between September, 1951, and May, 1952 at 17,600.

† From *Labour Turnover Rates in Manufacturing Industries.*

‡ Estimated from *Placing Work of Employment Exchanges.*

§ From *Age Analysis of Employed Persons.*

‖ This is actually the resultant of 80,000 "dismissals, withdrawals, etc." and 30,000 new engagements. The latter—about half 1951 rates—were probably nearly all re-starts after interruption, or transfers between mills; but it is not impossible that some slight inward drift occurred—in effect, of the least competitive workers into the least competitive industry.

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three thousand registered under other trades. Another 20,000 or so were in other occupations. The remainder were people who would have "left" anyway—as retired, dead, invalided, or married—but against this several thousand potential recruits were diverted to other industries, and some further three thousand married women were unable to *restart* employment in cotton, remaining unemployed and unregistered. While the transfer to other occupations (totalling 25,000 or so) was balanced by the consequent loss of employment to people already in them, or who would otherwise have got work there—a loss also largely unreflected in the unemployment registration.*

All this, of course, really describes the effects of a competition for jobs provoked by the collapse of a major industry's activity. These effects were twofold. First, that some of the resulting "final" unemployment appeared in other trades than the originating industry. Second, that the greater part of it remained hidden because the cotton slump drove "marginal" workers off the *general* labour market.† But many of these hidden unemployed would have been engaged part-time only, and altogether loss of jobs remained a secondary form of unemployment. One could calculate such "final" unemployment as being equivalent to nearly 16 per cent. of cotton's peak volume of work, only about one-third of this loss being experienced by people who lost jobs as cotton operatives and failed to get others—which explained the impression current among officials. By contrast, the comparable "equivalent" of short-time and under-employment was 28 per cent.‡

However, in considering the *general* relevance of these estimates, two other points are worth noting. In the 1952 recession firms in other industries than cotton commonly reported a fall in "labour turnover" in the sense of voluntary resignations.§ And this was quite widely attributed to the disciplinary effect of moderate unemployment.

Cotton operatives are by habit less volatile than is general.‖ But, of the 20,000 who took up other work, nearly all were young workers of the type managements were most anxious to retain.¶ And further evidence that these people left of their own accord was given by Insurance Officers' decisions; nearly half of all those disallowing benefit did so because the applicant had "left employment voluntarily".ø It seemed, then, that so long as the continued employment of "marginal" workers in other trades offered these younger operatives the chance of new jobs they were unwilling to accept depressed conditions in cotton. While the reduction in "labour turnover" elsewhere may well have been due to the consequent ability of managements to replace such "marginal" workers by people less liable to interruption of employment.

The 1952 recession was associated with a slight general fall in purchasing power (such as employment policy may perhaps restore but can hardly anticipate) which struck certain industries very hard. If these industries had been, not great employers of married women but (like the motor-car or radio trades) mainly users of male or young female labour, it would not follow, then, that the "wholly unemployed" registration (either in the trades most affected or in general) would have been higher. While the high proportions of short-time and under-employment in cotton partly reflected the inability of much of its labour to escape from the industry. So that a recession with a different subject might actually make a smaller impression on the records of unemployment and short-time.

The supposition is not merely speculative. Thus the textile-finishing trade experienced, in 1952, a collapse of activity rather less violent than that in cotton-weaving—to which, however, the fall in its payrolls was proportionately similar. Many of its plants are also in the cotton districts. But most of its labour is male; it returned relatively low figures of short-time and registered unemployment.

* A rough check on all these estimates was again given by the subsequently-issued *Age-Analysis* for 1952. (See *Cotton's Labour Force.*)

† It also raised the threshold of "marginality". Employment Committees *outside* the textile districts reported difficulty in placing single women over 30.

‡ These are the "full-time equivalents" already used, but calculated against October/November, 1951. In reckoning the equivalent of "final" unemployment, of course, allowance is made for the special decline of part-time engagements.

§ The Ministry's "labour turnover" statements, while representing the sum of particular firms' reports, do not distinguish between dismissals and voluntary resignations. Dr. Hilde Behrend, however, observed a similar effect in the Midlands.

‖ For the 12 months December, 1950 to November, 1951 (a period of intense labour shortage) "labour turnover" in cotton was 32·8 per cent. compared with 36·6 per cent. in manufacturing industry generally. (Calculated from *Labour Turnover Rates in Manufacturing Industry*, on employment at end-May, 1951).

¶ It later transpired that they were practically all under 40. (See *Cotton's Labour Force.*)

ø According to P.E.P. The total of decisions includes those on the "temporarily stopped", so this must have been the major cause of disqualification among "wholly unemployed" applicants.

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5. "*Holidays*"

Up to May of 1952 registered unemployment in cotton had at least risen as the industry's payrolls declined. But in the summer months the records took on a certain contrariness. Employment continued to fall—as did production and machine-activity, which reached their lowest point in July. But in that month the count of operatives "temporarily stopped" was 33,000 down on the May figure.

This registration was, of course, affected by holidays—which, in effect, took the place of short-time. Some 250,000 operatives were still on the payrolls in July. Short-time certainly fell; no return was made in this month, but it could be roughly estimated by alternative methods (for instance, by assuming it bore the same relation to the "temporary" unemployment register as in May) that in each week of July about 70,000 operatives lost working time. Against this, however, it could also be reckoned that some 60,000 *other* workers were "on holiday" for each week of the month.*

But a great many operatives had been working only intermittently in the months preceding their holiday. Just why should they cease to register at this time? Many of them, of course, were away; people seem to have made it a rule to go away for one of their two weeks off if they could possibly afford it. However, a major reason was that registration had lost its point. Under a 1951 agreement cotton employers were to set aside weekly a sum equal to 5 per cent. of each worker's earnings to cover the various annual holidays. The Insurance authorities ruled the summer payments to constitute "wages" for the fortnight in which they were made, and disqualified workers who could not show twelve days' *continuous* unemployment up to the holiday from benefit.

Had the Insurance ruling being rigidly applied in all districts the July count of the "temporarily stopped" would probably have been lower still. But that month's registration of "*wholly* unemployed" was also affected. Operatives warned—as some were—that they would not be needed after the holidays were unlikely to have registered at once. They would get no benefit by doing so; and since "wakes" in the cotton towns means a pretty general shut-down, the immediate chance of new work was negligible. Between May and July the register of "wholly unemployed" rose by only 1,000; but the payrolls were cut a further 12,000—and alternative jobs were much scarcer after Spring.

The cotton holidays mostly came between late June and the end of July, but the counts of registered unemployment for August and September also coincided with "wakes" in certain districts. The registration of "temporarily stopped," however, began to fall in early June—just *before* the holidays started. This seems to have been an effect of the imminent closure. An eve-of-holiday spurt in production is normal, because firms want to complete outstanding orders, and piece-workers want a good wage-packet to go away with. That tendency the recession perhaps subdued, but machine-activity records confirm that many firms thought it good policy to arrange at least a full week's work before they closed.

The effects of the summer holidays thus extended over four months in the year—and since "staggering" of summer holidays has been now quite widely adopted, the cotton experience can here be taken as typical.

But two further points occur. First, the coincidence of the slump's worst phase with the holiday months seemed more than chance. The timing of the recession's onset differed widely between the various textile and clothing industries; in the wool trades, for instance, it began quite early in 1951. But in every case, registered unemployment was greatest in May, 1952, although payrolls continued to fall into July and August—as did production, and this by more than the holidays alone could explain. Indeed, a tendency for the summer holidays to draw the greatest force of recession was common to industry in general.†

* Calculated from *The Cotton Trade Holiday List*, 1952 and various data on local employment.

† The following is extracted from some calculations by Mr. D. C. Hague (in the *Financial Times*, January 5th, 1952) which seek to eliminate the *direct* effect of holidays by comparing *monthly* outputs in 1951 and 1952:

Output by Industrial Groups, 1952 (*Same Month of* 1951 *as* 100)

	January–March	*April*	*May*	*June*	*July*	*August*	*September*
All Manufacturing	99	99	94	93	90	91	93
Enginering, etc. .	108	105	102	100	92	92	94
Vehicles . .	101	104	100	97	93	90	97
Textiles . .	85	73	70	66	69	73	79
Chemicals . .	104	100	96	96	90	90	—

The gradual extension of paid holidays may effect these figures somewhat, but they suffice to illustrate the point.

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In effect, the holidays shaped the course of the 1952 recession itself. For this, there were several reasons. Firms that found their output insufficiently reduced by the usual systems of short-time, postponed a longer shut-down until the holidays forced them to close. An announcement of short-time or dismissals could be softened by timing it with a holiday. "Extended Christmas holidays" was a common euphemism at the start of the cotton slump, and many mills closed the whole of Easter week; while notice of indefinite suspension was often given by telling workers not to come back after the break "until sent for". Moreover, in the summer holiday period many external indicators of firms' prospects—markets, orders, the production of suppliers, customers, and rivals—were also liable to partial suspense. So a policy of "hanging-on until the holidays" was general; while until the holidays were over, final decisions were delayed.

The general adoption of the summer fortnight thus seems likely to make the summer months critical in any recession's development. But this is just the time at which *all* the indices of activity become most difficult to interpret.

Secondly, the position of workers "on holiday" under these circumstances—like that of workers under-employed—is determined by the provisos of collective agreements. The cotton system of regulating holiday pay by earnings, for instance, meant that it was not uncommon for workers "on holiday" to get less than the combined short-time wages and unemployment benefit they had previously drawn. They were, indeed, sometimes worse-off than operatives registered as "wholly unemployed," who could often draw both benefit and holiday credits. The summer holidays were thus less a relief from short-time than an extension of it.

A proviso resembling that of the cotton holiday agreement is common to several piece-working trades; while in nearly all industries holiday pay is liable to reduction if work has not been continuous in the previous year. In the context of a recession, "holidays" may thus become a form of unemployment.

6. *Some Oddments.*

Whatever the situation in the holiday months, there was little doubt about the subsequent recovery. Payrolls and production rose, short-time fell. The cotton trade had clearly surmounted its critical phase. There were, however, several curiosities about this period of the recession.

Consider first the national record. Despite the textile revival no *general* recovery of employment occurred until spring of 1953. Total manufacturing payrolls stayed at the level to which they had fallen the previous summer—indeed, over the winter of 1952/53 short-time working extended slightly. Seasonal engagements confuse the general records until December, 1952, but civil employment then fell by 100,000—and stayed down for several months. At first, about half this decline was reflected in an increase of "wholly unemployed". But over the following months the register fell steadily, and by April was actually 25,000 *below* the previous November's figure.*

The *temporary* unemployment register in cotton demonstrated a similar effect. It has been noted that the number on short-time there fell by a third between the May, 1952, return and that for the end of August; but the number registered as "temporarily stopped" fell by nearly half. The difference would have been natural if the operatives concerned were losing less time apiece than before, and so had less cause to register. But their average loss of working hours remained much the same as in May.

In the last case, the falling registration seemed mainly due to an increase in disqualifications from benefit. The Insurance administration had adapted itself to the new level of claims and absorbed the case-decisions of the slump's early days. Some operatives had exhausted their entitlement to benefit anyway; while those who had first registered on a wrong view of their eligibility had long discovered their mistake. Such things, however, seemed insufficient to account for the falling *national* registration of "wholly unemployed". Here the major factor was probably the declining hopes of "marginal" candidates for work. In any case, it appeared that after the first shock of recession the registration of unemployed had a tendency to fall away.

In Lancashire, however, there was quite an opposite trend. First, in the cotton trade itself employment showed an increase of 5,000 between July and October, 1952; but the number

* These effects the *Gazette* (April, 1953) remarked as a decline in the total working population. The implicit definition will be noted.

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registered as "wholly unemployed" fell by less than half that figure—and there was no significant drift back of operatives who had taken other jobs (apart from a few who had only seasonal work in the summer).* Nor was there as yet any revival of part-time engagements—which would have offered re-employment to the major group of unregistered housewives who had lost their jobs. Second, the North-Western labour market as a whole showed an increased *surplus* in late 1952:

	Vacancies Notified at N.W. Exchanges	*"Wholly Unemployed" Registered in N.W. Region*	*Ratio, Vacant Jobs to "Available" Workers*
October/November, 1951 . . .	56,000	36,000	16 to 10
May, 1952	33,000	59,500	6 to 10
October/November, 1952 . . .	25,000	70,000	4 to 10

Two things would account for these local peculiarities. In the cotton towns themselves some mills were already going back to full production in autumn of 1952. And operatives who had fallen out of work and failed (or ceased) to register were now signing-on in the *expectation* that jobs would soon be available. So that as workers were re-engaged from the Exchanges they were partly replaced, on cotton's "wholly unemployed" register, by new or resumed registrations. And some part of the Region's *generally* increased registration was possibly due to a similar revival of hopes among married women whose return to work had been postponed by the slump.

This could not have been the whole story, however, because the greater part of the Region's additional registrations were of men. The second factor was apparently that the recovery of the cotton districts had been offset by the spread of mild depression to other Lancashire trades—including sections of engineering—employment mostly male labour.† On the other hand, outside the cotton towns themselves a great proportion of the "marginal" workers had now been driven out of local competition—at least, for the time being. Over the year from the cotton slump's commencement in November, 1951, it seems that the number of women on the national labour market fell‡ by about 100,000. And many (if not most) of the lapsed employees must have been in the North-West. Their jobs had mostly been taken by workers who left the textile industries, and this replacement of "marginal" workers was reflected in lower "labour turnovers" and fewer vacancies for the later unemployed to take.

This new unemployment resembled, in a mild way, that experienced in the 'thirties. Those concerned were mainly breadwinners and self-supporting people, who lost their jobs when labour was generally not in short supply. Under such circumstances the registration of "wholly unemployed" is likely to mirror pretty closely changes in the number of jobs available. But when the economy offers work to any sizeable number of people who are not dependent on their own earnings (or the sort of public help which is usually conditional on proof of seeking work), then the registration may bear no precise (or even reciprocal) relation to the level of employment. It may decline when employment is falling; it may equally rise when employment recovers.

7. *Summary and Conclusions.*

In sum, this enquiry suggested that in May, 1952, nearly 200,000 cotton workers (close on two-thirds the trade's peak strength of operatives) were either out-of-work or losing paid work from short-time and under-employment.§ Moreover, some further 25,000 people were denied jobs in other trades by the transfer of workers from cotton. And it also appeared that unemployment increased somewhat over the early summer.

By contrast, the total *registration* of cotton workers as unemployed was 87,600 in May, 1952,

* Later evidence, indeed, suggested that even by the end of 1953 very few of the younger workers who "left the industry" had returned. (See *Cotton's Labour Force.*)

† *Total* employment in the Region (estimated as p. 39, footnote) did not change significantly between spring and autumn, 1952.

‡ The *Gazette's* estimates of total civil employment showed, month-by-month, a fall of 190,000; the counts of "wholly unemployed" rose by only just over 100,000. The number of *male* "employees", however, increased slightly.

§ Incidentally confirming unofficial estimates which circulated in the cotton districts at the time—like that, for instance, reported by W. M. Clarke (*Profile of the Recession*).

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and 55,600 in July. While the industry's *payroll* employment fell by less than 50,000 up to May and only rather over 60,000 up to July.

The unemployment registration had several defects as an index of "involuntary idleness". First it recorded only part of those affected by the *partial* employment which was the latter's most common form. Second, it did not fully record the number of people quite deprived of employment. Third, it became especially incomplete in what may well have been the critical months—those in which the summer holidays fell due. And finally, the registration did not fluctuate solely in inverse relation to the level of employment. This, for two reasons: once risen, it had a certain tendency to decline as workers discovered their disqualification for unemployment benefit or exhausted their eligibility; and it also varied *directly* with "marginal" workers' estimates of employment prospects.

Payroll employment was an equally inadequate index to loss of work because most of the workers affected remained at least nominally possessed of jobs. Of the three indices of activity most commonly referred to, that of production probably came nearest the mark. Even so, it was not a very precise guide to the amount of work. On the one hand, changes in quality and productivity combined with "acceleration" effects to prevent final output falling as much as employment.* On the other hand, collective agreements and industrial practices cushioned the operatives against some of the effects of falling production. The available production indices, therefore, would not deprive more accurate measurements of employment and unemployment of utility.

Some qualification is necessary to the above summary estimate. "Final" unemployment was mainly confined to such "marginal" employees as married women, many of whom were in any case engaged part-time only, and among whom denial of normal opportunity to *re-start* work rivalled the actual loss of jobs. "Staff" employees suffered no significant loss of work. While an estimate solely in terms of the *number* of operatives affected by the cotton slump would, of course, exaggerate the latter's impact, since "work-spreading" may make a little unemployment go a long way.

This paper's various estimates can be summarized, however, in three dimensions:

TABLE 3

Employment Effect of 1952 *Recession in Cotton Industry*

(*April/May* 1952, *as a Percentage of Activity, Labour Force and Wage-bill in October/November* 1951)

	A *Loss of Work from:* %	B *Operatives Affected by:* %	C *Loss of Wages from:* %
Short-time	22·0	43·5	20·0
Under-employment only	6·0	11·5	1·2
Loss of overtime only	0·3	1·0	0·4
"Direct" loss of jobs	5·5	6·5	5·5
Transferred Unemployment	(10·3)	(9·5)	(10·3)
All forms	44·1	72·0	37·4

The decimal points, of course, imply no claim to Greenwich accuracy. But of this table's total measurements, column A's estimated "loss of work" corresponds closely to the recorded decline in machine-activity, while column C's total is almost exactly confirmed by an alternative calculation of the fall in the wage-bill.† The main dubietics of column B are the numbers affected only by under-employment or lost overtime: these items are little more than reasonable guesses.‡ However, the table serves to show how the cotton recession was transmitted—via "work-spreading"

* The current national Index of Industrial Production actually includes measurements taken from points outside the industrial process proper—like manufacturers' deliveries or sales; while the constituents of the index seem predominantly derived from the finishing end. The index as a whole may thus be quite as liable to "accelerator" effects as its cotton sections. See also D. Seers' comment (*The Summer Recession in* 1952).

† By combining column A's data with those of the Ministry's earnings enquiry.

‡ The number who experienced both were too small to be worth distinguishing.

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on the one hand and wage-schedules on the other—to the operatives themselves or (in the case of "transferred unemployment") to people outside the industry. Column A indicates an idle human capacity, column C its income effect, and column B their dispersion.

The *distribution* of the loss of work between its various forms was, of course, influenced by the particular circumstances of the textile industry. But it has been remarked that, on the whole, there was no reason to think the indices of employment and unemployment *more* misleading in the cotton case than in others. One could conclude, for instance, that a mild *general* decline in activity (such as could herald a more severe recession), resulting only in reduced overtime, moderate under-employment and limited short-time, might make no significant impact on either of these two indices—or, immediately, on that of production. In particular, the experience of this study permits some estimate of the national unemployment index's deficiency about this time.

Throughout 1951 the total register of unemployed varied about 250,000. At the end of May, 1951 (for which date the Ministry of Labour's annual estimate of total "employees" was made) the registered unemployed numbered 216,000, and the index stood at 1·2 per cent. The sample results of the 1951 Census of Population, taken in April, show some 445,000 as "out-of-work"; but one need not here concern oneself with the reasons for this difference. The time was generally considered one of labour shortage; whatever its actual level, unemployment could hardly have been quickly reduced without direction of labour or industry. Thus only the *increase* of the unemployed between May, 1951, and mid-1952 need be considered.

In May, 1952, the national register of the "wholly unemployed" stood at 320,000. It has already been suggested that the actual number deprived of employment exceeded that by at least 125,000. Very few people signed-on as "temporarily stopped" in early 1951, but the May, 1952, registration was 147,000. Of these, all bar four thousand or so were in manufacturing industry—where the May census implies the actual number on short-time to have been about 388,000. At this time the national unemployment index was 2·2 per cent. The actual increase of workers finally-unemployed or on short-time would thus have brought the figure close to 4 per cent.; and this does not allow for unrecorded short-time in non-manufacturing trades (like transport and warehousing) in which its only index is the temporary unemployment register, or for people working in the week of the quarterly census but on short-time "rotas". The further effects of under-employment and lost overtime on wages can also be roughly guessed. In manufacturing industry, the former probably involved a loss of 1 or 2 per cent.* and the latter nearly 0·5 per cent. of the 1951 wage-bill.†

The data available do not permit a "three-dimensional" estimate of the national decline in employment, like that made above for cotton.‡ But at the least, it is fairly certain that the national unemployment index recorded only about one-third the *increase* of workers unemployed or on short-time up to May, 1952. While in the following months it moved in the wrong direction. By July, it had fallen to 1·9 per cent.: all the evidence is that loss of work was actually increasing.

Of such discrepancies it is only a partial explanation that the registers measure "unemployment" in a narrower sense than that used here. But whether a decline in employment is manifested in ways likely to affect the registration or in such things as under-employment and reduced overtime largely depends on the circumstances of the trades particularly concerned. And the different forms of "involuntary idleness" are not sharply demarcated. Short-time in the docks, for instance, will not lead to a registration of unemployed; it will have, under "guaranteed wage" schemes like that ruling in this industry, the same effect as under-employment.

Nor is the distinction between the forms that may influence the registration and those that will not a matter of their differing severity. In retrospect, for example, the post-war cut in the standard working week has so far had the *average* effect, less of reducing working hours than of generally increasing wages—but in a manner which makes the last hours of the day or week particularly costly to employers. Most of the overtime, however, is done by *men*, and as between industries there is a considerable variation in hours worked. On the whole, the trades where hours are long by contemporary standards seem to be ones in which *basic* pay is relatively low—

* Derived from D. C. Hague's calculation (see p. 42, footnote) by assuming that production indices understated the fall in activity, and that wages were affected, to the same extent as in cotton.

† See Appendix.

‡ Mainly because of the absence of published data on the number of employees on part-time engagements; some information is, however, collected in the "L return" and the "earnings and hours" census.

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and vice versa.* A reduction in activity such as would lead, in a trade with long working hours, to the abolition of overtime would thus have an effect on the workers' pay both disproportionate and serious. But in a well-paid industry with short working hours, a similar decline would generally involve moderate short-time; and the workers' income would be *less* than proportionately reduced, since they might claim at least the public unemployment benefit.

But in any case, no definition of unemployment *as such* is implied in its official record. The registration is *affected* by Insurance definitions, but these may award benefit to a worker who is losing less time than another from whom they withhold it; and the number signing-on may be greater or less than that "unemployed" in the sense of Insurance qualification. Nor can the registers be taken to indicate the number of people available and willing to take up work. In a recession many people included in the unemployment percentage will have jobs already; while the registers of "wholly unemployed" will reflect not only the availability of workers but also *their* view of the availability of work.

The inadequacy of registered unemployment as an index of activity arose mainly from two things. First, that the effective labour market included such a wide fringe of "marginal" workers.† Second, from the partial character that unemployment largely assumed. In part, these things were the result of the preceding labour shortage. But the belief that the government would not tolerate a persistent surplus of labour also disposed employers to confine dismissals to "marginal" workers, and otherwise to meet the recession by "spreading the work". And this policy was also supported—sometimes, indeed, proposed—by trade unions and workers. The forms of "involuntary idleness" described in this study may thus prove typical of the modern political economy.‡

* * * *

It would be as well here to make clear the nature of such comments on and criticisms of current official statistics as have been made in this study. The very considerable volume of official material now available gives much useful and varied information, and in the present case provided at least a basis for inference. Its more recent elaboration, however, was necessarily made in the light of past experience—in which the inter-war period bulked large. That period has especially influenced the public interest in particular series, and the importance accordingly attached to them. The events of 1951–53 may indicate certain detailed respects in which current series might be improved, and it is not proposed to reiterate these. The more important effect of that experience is to suggest that fluctuations in employment may now express themselves in a way sufficiently different from the past to require a re-appraisal of the relevant indices. For instance, it now appears that perhaps the most significant of the available employment series is the modest, infrequent and incomplete return of short-time and overtime.

It was put, in introducing this study, that such series may have three uses: as pointers to the economic situation, measures of a social problem and gauges of unused labour. Our current index of registered unemployment is—though the most prompt of published reactions to employment trends§—clearly unreliable for each of these purposes. The registers provide a ready source of first data on such things as the spread of unemployment between age-groups or districts. But even here they are far from conclusive, and for all more general (or more precise) purposes they should certainly take a back seat.

* In October, 1951, average hours worked in the trades distinguished by the Ministry's six-monthly census varied for men from 41·8 to 56·9 per week. In the nine trades where hours exceeded 50, average earnings for *standard* hours must all (with one doubtful exception) have been below normal. In each of the four trades where men's hourly earnings exceeded 50d., however, hours worked were much below average—appearing in only one case to exceed the standard week.

† The sources disagree on the number of married women and people over "retiring age" in employment, and the overlap between these categories is uncertain, but it seems that in 1951 they totalled between three and three-and-a-half million (or about 15 per cent. of all employed). About half would be ineligible for unemployment benefit.

‡ They are not associated solely with "full" employment in the British sense. A law (August 10th, 1951) of the German Federal Republic restricts "mass dismissals" of workers, and authorizes short-time under certain circumstances. Considerable under-employment was imposed on post-war Italian industry. There is some discussion of the "marginal" labour market in the U.S.A. in *How Much Unemployment?*

§ The count's results are issued in the following month's *Gazette*. The lag for employment and short-time data is two months, for hours and earnings, five.

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It does not seem, however, that any direct measurement of unemployment can be quite satisfactory—if only because no definition of unemployment which is both formally satisfying and practically workable offers itself. One can, however, start from the supposition—since we now know roughly what "full employment" looks like—that significant unemployment exists when, and to the extent that, employment declines.

As an index of employment, the current payroll estimates alone are unsatisfactory (minor points apart) because they do not indicate the *degree* to which the workers they cover are in fact employed. Of that, total hours worked are first indicator, though they cannot be derived from existing published series.* But a short-time and overtime return gives an approximation to that figure: the existing series were combined with payrolls in Table 1 to measure employment in cotton, and also yield (an example is attached as an Appendix) a rough guide to the true level of employment in manufacturing as a whole. Since non-manual workers seem broadly to be treated as an "overhead", this is the major part of employment's fluctuating sector.

This method leaves, however, two problems. In the absence of such process indices as the textile "machine-activity" series, under-employment could only be measured by direct enquiry. It is likely, however, to be accompanied (or at least, introduced) by other symptoms of declining employment; and if its presence were suspected, sampling seems the obvious means of investigation.

The second question concerns the holiday period, when an adverse trend of employment would not be revealed by the combined payroll and short-time series. But though for industry as a whole this period extends over nearly one-third of the year, the critical thing, in the presence of a possible recession, would be the decisions *individual* firms made when their own holidays were over. In a total of firms' behaviour these decisions would be overlaid by the situation of concerns still anticipating or enjoying their holidays. But a study of payroll and short-time returns from establishments which had *finished* their holidays in each month should reveal the effective trend.

It seems possible, then, to devise a fair guide to the general tendency of employment. Its translation into social terms presents other problems. One result of the forms a decline in employment is likely these days to assume is to spread and cushion its income effect. However, a moderate general decline may yet have severe effects on particularly groups of workers. In so far as such a result is not illuminated by the available data on earnings, National Insurance and Assistance disbursements, P.A.Y.E. payments and repayments, and collective agreements, sample surveys again seem the only satisfactory means of enquiry —as was indeed suggestion in the Lancashire case.†

There remains the question of the use of an employment index as a measure of labour's availability. Such an index stands, of course, in relation to some measure of the number of people who *might* work—such as the total adult population. Here a final reservation is required: there is no exact point of "full" employment because—at current average incomes, at least—a high demand for labour expands its supply.

* The current "earnings and hours" census, while giving the number of workers covered, does not report the payroll strength of returning firms.

† By P.E.P.

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APPENDIX

Employment in Manufacturing Industry 1951/52 (*Assuming a Standard Working Week of* 45 *Hours*)

	Week Ending			
	Sept. 22nd, 1951	*Jan. 26th,* 1952	*May 24th,* 1952	*Aug. 30th,* 1952
Operatives Employed (000's)	7,250	7,290	7,130	7,070
Operatives on short-time (per cent.)	1·1	3·7	5·4	3·3
Average hours of short-time	12·8	12·9	17·1	16·3
"Full-time Equivalent" of short-time (per-cent., on nominal employment of operatives)	−0·3	−1·1	−2·1	−1·2
Operatives on overtime (per cent.)	21·8	19·9	20·8	20·2
Average hours of overtime	7·8	7·7	7·7	7·8
"Full-time Equivalent" of overtime (per-cent., on nominal employment of operatives)	+3·8	+3·4	+3·6	+3·5
Balance of short-time and overtime "Equivalents" (per cent.)	+3·5	+2·3	+1·5	+2·3
"Equivalent" to nominal employment at standard working week (000's of operatives)	7,500	7,450	7,240	7,230
"True employment" index	100·0	99·3	96·5	96·5

From *Employment in Great Britain: Industrial Analysis* and *Short-time and Overtime in Manufacturing Industries*. Nominal employment of operatives estimated by deducting proportion of "staff" employees shown by N.W. Regional payroll returns. Average hours of overtime and short-time recalculated, since the Ministry "rounds-off" its result to the nearest half-hour.

This is calculated mainly for illustration. The national proportion of operatives among the employed and their average standard week are probably over-estimated, and there is no allowance for normal absence or part-time employment. These factors are probably not offset by the under-recording of overtime, so the base is too large. The later fluctuations are also understated by the non-inclusive of any estimate of under-employment. However, it does not seem that any of these factors except the last would greatly affect the "index" for January and May, 1952; thus an accurate figure for May would probably be closer to 96·0 without under-employment, but about 95·0 with under-employment. In August, however, a million operatives were probably "on holiday" during the week; how far their condition was affected by the recession is uncertain.

SOURCES AND REFERENCES

I. *Published Statistical Series*

(a) In the *Ministry of Labour Gazette:*

General Manpower Position*	Monthly.
Analysis of Numbers in Civil Employment*	"
Numbers Employed in Great Britain: Industrial Analysis*	"
Unemployment: Summary for Great Britain*	"
Numbers Unemployed: Industrial Analysis*	"
Numbers Unemployed in the U.K.: Regional Analysis*	"
Labour Turnover Rates in Manufacturing Industries	"
Placing Work of Employment Exchanges*	"
Insured Persons Absent from Work owing to Sickness or Industrial Injury*	"
Short-time and Overtime in Manufacturing Industries	Quarterly.
Earnings and Hours	Six-monthly.
Duration of Unemployment and Age of Unemployed: Analysis for Regions and Development Areas	"
The Employed Population	Annually.
Age-Analysis of Employed Persons	"
Young Persons Entering Employment	"

* Reproduced, variously selected or compressed, in the *Monthly Digest of Statistics*. But see footnote, p. 29.

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(b) In *The Cotton Board Quarterly Statistical Review:*†

Spinning	Employment:	Average number actually working.‡ Numbers on the books.‡ ,, engaged. ,, leaving.
Waste Spinning Doubling	,,	Numbers on the books.‡ ,, actually working.‡
Weaving	,,	Lancashire Area: Numbers on the books. Numbers actually working. Total U.K.: Numbers actually working.
Spinning Waste Spinning Doubling	Yarn production.‡§	
Weaving	Cloth production.‡§	
Spinning Doubling	Machine-activity	Spindles in place.‡ ,, running.‡§ Spindle-hours.
Waste-Spinning	,,	Spindles in place. ,, running. Spindle-hours.
Weaving	,,	Lancashire Area: Looms in place. Looms running. Total U.K.: Looms running.‡§ Loom-hours.
Weaving	Yarn consumption‡§	

Supply and Consumption of Rayon: Rayon Staple consumed in the Spinning Industry.

† As weekly averages or totals of quarter. Weekly figures for several of these series circulated in the Cotton Board's *Weekly Press Statement.*

‡ Monthly figures (some in summary form) *Board of Trade Journal.*

§ Monthly figures (some in summary form) *Monthly Digest of Statistics.*

(c) In the *Monthly Digest of Statistics:* Raw Cotton, Home Consumption: Cotton Spinning.

(d) In the *Board of Trade Journal:* Output and Employment in the Cotton Industry; Numbers "on books": Weaving, Total.

II. *Other References*

General Register Office, and General Registry Office, Scotland (1952): *Census of Great Britain*, 1951. *One Per Cent. Sample Tables.* London: H.M.S.O. Part I, Section III (Industries).

Ministry of National Insurance: (1951) *National Insurance Acts: Unemployment Benefit.* M.N.I., N.I.12. (1952) *Third Report.* London: H.M.S.O.

Central Statistical Office (1951): *The Index of Industrial Production, Studies in Official Statistics* (2). London, H.M.S.O.

Manchester Royal Exchange (1952): *The Cotton Trade Holiday List.*

Political and Economic Planning (1952): "Social security and unemployment in Lancashire", *Planning* (349) **19**, 113–136.

AINSWORTH, R. B. (1950), "United Kingdom labour statistics", *J.R. Statist. Soc.*, A (1), **113**, 37–49.

BEHREND, H. (1954), "Limits to a firm's control of labour turnover", *Nature*, Lond. (4400) **173**, 379–381.

BUZZARD, R. B. (1954), "Attendance and absence in industry: The nature of the evidence", *Br. J. Sociol.*, **5**, 238–252.

CLARK, C. (1937), *National Income and Outlay.* London: Macmillan, Table 19.

CLARKE, W. M. (1952), "Profile of the recession", *District Bank Review* (104).

GRAY, E. M. (1937), *The Weaver's Wage.* Manchester University Press, 20–30.

LOMAX, K. S. (1953), "Recent productivity changes in the British cotton industry", *Bull. Oxf. Univ. Inst. Statist.*, **15**, 147–150.

—— (1952), "Lancashire survey", *Times Review of Industry*, **6**, 10–11.

SEERS, D. (1953), "The summer recession in 1952", *Bull. Oxf. Univ. Inst. Statist.* **15**, 85–104.

SMITH, R. & TURNER, H. A. (1953), "The slump in the cotton industry, 1952", *Bull. Oxf. Univ. Inst. Statist.*, **15**, 105–132.

TURNER, H. A. (1953), "Unemployment in textiles: A note and some conclusions", *Bull. Oxf. Univ. Inst. Statist.* **15**, 295–306.

—— (1953/4), "Cotton's labour force", *Textile Mercury, Manchester* (3354) **129** and (3391) **130**.

A symposium of eight papers (1950), "How much unemployment?", *Rev. Econ. and Statist., Harvard* (1) **32**, 49–79.

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The Pattern of a Divided Economy: A National Income Analysis of India and Pakistan

By R. H. Khandker

Since the pioneer work by Dr. V. K. R. V. Rao in 1940 (*The National Income of British India*, 1931–32) in estimating the national income of Undivided India, excluding the princely states, for 1931–32 an enormous change has taken place in that sub-continent. Though the division of the sub-continent in 1947 into India and Pakistan refers to the geographical area the real implication is far deeper. Had it been just a division of the area, economic pattern in the two countries would have been determined by the human and natural resources in each side. As the division took place mainly on the basis of religion the geographical division has been complicated by an enormous movement of population across the border. In Undivided India there was an uneven distribution of income not only by area but also by religious and caste groups. The socio-economic pattern prevailing for more than a century has been shattered by the division. The complex result of the division made it impossible to guess correctly the relative economic well-being in the two countries and the patterns of the two economies.

Pakistan, again, is composed of two zones separated by more than a thousand miles having India in between. This geographical peculiarity has also caused economic peculiarity. Though for all purposes Pakistan is one country the economy is so divided that one might discover differences in price levels, wage rates, employment, etc. to such an extent that one might call them two economies.

The purpose of this paper is to make a comparison of the general economic pattern of India and Pakistan, and also a comparison of the economic pattern of East and West Pakistan. The analysis will be based on the estimated figures of national income and its distribution for the two countries for 1950–51. A note of warning should be given here. National income estimates for India have been made by a National Income Committee and figures for 1950–51 will be quoted from their final report (February, 1954). National income and its distribution for Pakistan have been estimated for the same period by the present author and as such may not be fully comparable with their Indian counterparts. There is not much difference in the methods adopted, but a greater difference may be in the nature of source data. Although it is likely that the comparison of the absolute level of economic strength may not be of much value, the indication of the general pattern of the economy given by these estimates may be comparatively freer from defects.

The methods adopted in estimating the national income of India have been fully described in the *Final Report of the National Income Committee of India* published in February, 1954. The methods adopted in estimating the national income of Pakistan may be sketched here.

None of the customary methods of estimating national income, that is, estimating from the income, production and expenditure sides, clould be adopted fully. The statistical material is inadequate and faulty, and we have had to rey on a different approach in dealing with a different sector of the economy. The nature of the data is such that a greater part of the field could be dealt with with moderate accuracy by production approach. The rest of the field has been covered by income approach. There were gaps in the statistical field which have had to be filled on the basis of indirect information and guesses.

In the first place, the entire economy has been divided into many sectors. This has been done by classifying the working force into fifteen occupation groups. Such classification was shown in the reports of the population census of 1951. However, occupational classification for an underdeveloped country cannot be perfect, as people are generally engaged in several types of work for gaining their livelihood, of which only one or two are generally recorded. In Pakistan census reports, occupational classification refers to the main occupation only.

The contribution of the agricultural sector (including animal husbandry) has been arrived at mainly on the basis of production and harvest prices. From the gross value of the produce, deductions have been made for costs of seed, wastage, manuring, irrigation, processing, marketing, maintenance of animals and depreciation of equipment. Fishery, forestry and mining have been

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similarly treated—that is estimated on the basis of production and price deducting, cost and depreciation, thus arriving at the net value added. The product of each sector has again been broken into factor earnings on the basis of miscellaneous information.

The contributions of other sectors have been estimated from the income side on the basis of the number of persons engaged and their income per head. Classification has been by wage-earners and salary-earners to estimate wage-bills and salary-bills on the basis of wage rates and salary rates in different sectors. Profit and interest have been estimated on the basis of data regarding companies and some assumed ratio between labour income and non-labour income in a particular sector.

Income originating in government administration has been estimated on the basis of wages and salaries paid by the public authorities. The detailed budget estimates of the central and the provincial governments for 1952–53 contains actual figures for 1950–51. Contributions by smaller local authorities are less accurately estimated as they are based on inadequate data. Public enterprises, such as railways, post and telecommunications, etc., have been treated like the private enterprises, except that their contributions have been estimated on the basis of budget accounts.

The rental value of urban houses has been estimated on the basis of expenditure per person on house rent as revealed by some family budget survey. The rental value of rural houses has been imputed on the basis of their number and the interest on their capitalized value and deducting the cost of maintenance.

The total net domestic income at factor cost of Pakistan for 1950–51 amounts to Rs.19,169 million. The net factor income from the rest of the world as revealed from the balance of payment statistics is negative (—Rs.18 million) and the net national income of factor cost amounts to Rs.19,151 million.

Before analysing the income pattern of India and Pakistan it is necessary to give the occupational distribution of the working force in the two countries. A comparison of the distribution of the working force by occupation is shown in Table 1 as percentages of the total, not by the actual

TABLE 1.

Occupational Distribution of the Working Force (percentage)

	East Pakistan	*West Pakistan*	*Pakistan*	*India*
(1) Agriculture and animal husbandry	83·2	67·7	76·7	71·8
(2) Forestry	0·1	(*a*)	0·1	0·2
(3) Fishing	1·5	0·2	0·9	0·4
	84·8	67·9	77·7	72·4
(4) Mining	(*a*)	0·1	(*a*)	0·5
(5) Manufacturing	5·0	10·6	7·4	10·1
	5·0	10·7	7·4	10·6
(6) Communication	0·1	0·1	0·1	0·1
(7) Railways	0·5	1·2	0·8	0·8
(8) Banking and insurance	0·1	0·2	0·1	0·1
(9) Other commerce and transport*	4·9	8·0	6·2	6·7
	5·6	9·5	7·2	7·7
(10) Professions	0·9	1·0	1·0	4·5
(11) Government	1·4	2·9	2·0	2·7
(12) Domestic service	1·5	5·0	3·0	2·1
(13) Other service	0·8	3·0	1·7	(*b*)
	4·6	11·9	7·7	9·3
(14) Working force	100·0	100·0	100·0	100·0

* Wholesale and retail trade, and non-railway transport are combined, as breakdown is not available for India.

(*a*) Less than 0·05.
(*b*) Does not exist in Indian classification.

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numbers for difference in definition. The number of persons engaged in any sector in India is defined as being equal to the total number as self-supporting and also as "earning dependant" and subsidiary employment. Census reports of Pakistan show the distribution by main occupation only, with some additional information about subsidiary employment. Thus the working force in India is by definition greater than that in Pakistan. This does not affect the national income total as a greater part of it is estimated from the production side; and for that part covered by income approach these factors are taken account of in determining the per head income. The difference in definition becomes all the more immaterial if we look to the assumption made in India that "the distribution of earning dependants within each livelihood class is similar to that of self-supporting persons of the same class."

Table 1 indicates that East Pakistan is more dependent on agriculture than West Pakistan. In forestry and fishing East Pakistan is at some advantage. West Pakistan is far more industrialized and the degree can be roughly said to be double that of East Pakistan, if, of course, employment is any indication of the degree of industrialization. In tertiary occupations also, such as communication, transport, commerce and banking and insurance, East Pakistan is at a great disadvantage. There is also a substantial difference in the provision of services, though little in professions. The difference in the government services is largely owing to there being two provincial and two state governments in West Pakistan while the whole of East Pakistan is under one provincial government; and employees of the central government are largely concentrated in the Federal capital, Karachi, which is in West Pakistan. There is a great difference in the method of using domestic service in the two parts of the country. This difference may also be partly due to definition. "Other services" does not indicate anything except the degree of efficiency with which the census of population was conducted, as this item includes all "unclassified" casual workers.

It is most interesting to note that the difference in the occupation pattern between India and Pakistan is far less than it is between East and West Pakistan. Though Pakistan as a whole is less industrialized than India this is wholly due to the industrial backwardness of East Pakistan. Table 1 suggests that West Pakistan is at least as industrialized as India.

If we turn from the occupation pattern to the income pattern similar things may be expected. As the estimated national incomes of both countries for 1950–51 refer to the respective national currencies which differ in value owing to India's devaluation of her rupee in September, 1949, as a sequel to sterling devaluation, and the non-devaluation policy of Pakistan, it is extremely difficult to compare the actual income in the two countries. The official exchange rate is 100 Indian rupees to 69·5 Pakistani rupees. This by no means reflects the actual purchasing power of the two currencies as the official rate is maintained by strict exchange control. On the other hand, the general price level in India in 1950–51 was definitely higher than in Pakistan. A calculation of the real purchasing power parity is difficult to make. However, both the rupees had the same value in 1948–49 before devaluation. A flat average of index numbers of retail prices of goods purchased by the working class peoples in 24 centres suggests that in India prices have risen by 2 per cent. in 1950–51 over 1948–49 (index 102, 1948–49 = 100).* In Pakistan similar index numbers of retail prices in 1950–51 over 1948–49 are 95 for Karachi, 81 for Lahore, 78 for Sialkot, 81 for Khewra and 98 for Narayangung.† Of these centres only the last one is in East Pakistan. A flat average will give a misleading result as East Pakistan accounts for more than half Pakistan's national income. However, by taking weights, Karachi 1, Lahore 1, Sialkot 1, Khewra 1 and Narayangung 4, the weighted average after rounding comes to 90. This index viewed against 102 in India shows that prices were 11 per cent. lower in Pakistan than in India (Index = 89). In other words it means that 100 Indian rupees were equal to 89 Pakistani rupees in Pakistan. Table 2 gives income of different sectors in Pakistan and her two zones and also income in India in terms of Indian rupee and Pakistani rupee converted by official exchange rate and the purchasing power exchange rate calculated here.

The *per capita* incomes of Pakistan and of India in national currencies (Table 2) are Rs.253 and Rs.265 respectively. The *per capita* incomes in East and West Pakistan are Rs.239 and Rs.268 respectively. This shows that the Eastern zone is definitely poorer than its Western counterpart. The Indian *per capita* income in terms of Pakistani rupees converted by the official and

* Calculated from data given in the Monthly Abstract of Statistics, India.
† Statistical Bulletin (Central Statistical Office).

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purchasing power exchange rates shows Rs.184 and Rs.236 respectively. While for comparison the former should be discarded, the latter is also difficult to trust. It shows a *per capita* income in India lower even than that in East Pakistan. The real picture may be a little different. In calculating the purchasing power parity we have used the indices of *retail prices* for deflation whereas national income is estimated at factor cost. There may be variations in the rates of indirect taxes and subsidies on the two countries. Again, the price indices relate to both home made and imported goods. The price of the latter category might have risen disproportionately as a result of devaluation. The national product or income relates only to the domestic goods and services. The comparison of *per capita* income might give some indication of relative welfare but not of relative productivity.

TABLE 2

Distribution of Domestic Income by Industrial Origin (100 *million rupees*).

				India		
	East Pakistan	*West Pakistan*	*Pakistan*	*Pak. Rs. at P.P.*	*Pak. Rs. at Official rate*	*Indian Rs.*
(1) Agriculture and animal husbandry	64·8	45·5	110·3	425·1	351·9	477·6
(2) Forestry	0·3	0·2	0·5	6·1	4·8	6·9
(3) Fishery	4·5	0·1	4·6	3·2	2·5	3·6
(4) Mining	0·1	0·2	0·3	6·4	5·0	7·2
(5) Manufacturing	8·7	14·4	23·1	130·4	101·8	146·5
(6) Communications	0·2	0·3	0·5	3·6	2·8	4·0
(7) Railways	1·1	1·8	2·9	16·0	12·5	18·0
(8) Banking and insurance	0·3	0·4	0·7	5·8	4·5	6·5
(9) Wholesale and retail trade	6·4	8·3	14·7	111·4	87·0	125·2
(10) Non-railway transport	1·4	1·1	2·5	13·0	10·1	14·6
(11) Profession	2·0	1·4	3·4	41·7	32·5	46·8
(12) Government	5·1	8·7	13·8	38·3	29·5	43·0
(13) Domestic service	1·0	2·3	3·3	11·6	9·0	13·0
(14) Other services	0·8	2·0	2·8	..	..	..
(15) House property	4·1	4·2	8·3	36·3	28·4	40·8
(16) Net domestic income	100·8	90·9	191·7	848·8	662·8	953·7
(17) Net income from abroad	..	..	−0·2	−17·8	−13·9	−20·0
(18) Net national income	..	..	191·5	831·0	648·9	933·7
(19) Income *per capita*	Rs.239	Rs.268	Rs.253	Rs.236	Rs.184	Rs.265

Such comparisons of income may be misleading only for the reason that they are not estimated by the same agency. It may, however, be concluded that *per capita* income is higher in West Pakistan than India. The same may not be true for East Pakistan. The difference of prices between this part of Pakistan and India is much less. A rupee in Pakistan is as a whole different from what it is in the zones. The tentative conclusion is that India is poorer than West Pakistan, but may be richer than East Pakistan. The difference between Pakistan as a whole and India is uncertain and may perhaps be of negligible magnitude.

The preceding discussion compares the absolute level of income in India and Pakistan. To compare the pattern of the economy we can with advantage express the contribution of each sector as a percentage of the total. This approach is free from the complications arising from the difference in the value of local currencies. Table 3 shows the contribution of each sector as a percentage of the total. A satisfactory comparison of income per employed person in India and Pakistan is not possible owing to a different definition of the working force. However, a comparison of Table 3 with Table 1 will give some rough idea of the relative profitability of each

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sector. Agriculture is more profitable in Pakistan. Though there is little difference in manufacturing, profitability in commerce and transport is definitely higher in India. In government and other provision of services Pakistan seems to be better served than India.

TABLE 3

Contribution of Each Sector to the Net Domestic Income (percentage)

	East Pakistan	*West Pakistan*	*Pakistan*	*India*
(1) Agriculture and animal husbandry	64·8	50·2	57·4	50·1
(2) Forestry	0·3	0·2	0·3	0·7
(3) Fishing	4·5	0·1	2·4	0·4
	69·6	50·5	60·1	51·2
(4) Mining	0·1	0·2	0·1	0·7
(5) Manufacturing	8·7	15·9	12·1	15·4
	8·8	16·1	12·2	16·1
(6) Communication	0·2	0·3	0·3	0·4
(7) Banking and insurance	0·3	0·4	0·4	0·7
(8) Wholesale and retail trade	6·4	9·1	7·7	13·1
(9) Non-railway transport	1·4	1·2	1·3	1·5
(10) Railways	1·1	2·0	1·5	1·9
	9·6	13·0	11·2	17·6
(11) Profession	2·0	1·5	1·8	4·9
(12) Government	5·1	9·6	7·2	4·5
(13) Domestic services	1·0	2·5	1·7	1·4
(14) Other services	0·8	2·2	1·5	..
(15) House property	4·1	4·6	4·3	4·3
	13·0	20·4	16·5	15·6
(16) Domestic income	100·0	100·0	100·0	100·0
17) Net income from abroad			−0·1	−0·2
(18) National income			99·9	99·8

The total working force excluding "earning dependants" in India is known. This is 104·80 million against 22·04 million in Pakistan. The income per self-supporting person in national currencies is Rs.900 in India and Rs.871 in Pakistan. The Indian figure when converted into Pakistani rupees at the rate of purchasing power parity (89 per cent.) amounts to Rs.801. Much reliance cannot be placed on such comparisons.

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Measuring Social Mobility*

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1. *Social Mobility as Shown in a Transition Matrix*

A conclusion which clearly emerges from the series of investigations recently published under the title *Social Mobility in Britain* (edited by D. V. Glass, 1954) is that while the concept of social mobility is complex its study is best furthered by the kind of quantitative approach so widely adopted there. This, again, is in accord with views expressed in earlier investigations such as that of Ginsberg (1929). Perhaps the most interesting table of statistics resulting from such quantitive studies is one setting out the relation between the social statuses of fathers and their sons as derived from a series of interviews of a sample of the population. An example of such a table is given below as Table 1 which is taken from the volume edited by Glass; it is based on the results of a random sample of some 3,500 males, resident in England and Wales and aged 18 years and over, interviewed by the Social Survey in 1949.

In this paper such a table will be termed a transition matrix, for the coefficients of such a matrix will be regarded as giving the probability of a family's transition from one social status to another. With the help of the assumption that these probabilities are constant over time,† a number of new summary measures will be derived which seem to have advantages over those currently used in assessing the degree of social mobility.‡

This note is restricted to the setting out of the method of analysis and to its application to the main table just mentioned. The many qualifications to which the figures in this table are subject have been amply set out by Glass and Hall and there is no need to repeat them here; as far as I can see they do not affect the interpretations suggested in this paper to any substantial extent. A point worth bearing in mind, however, in interpreting the calculation given below is that "social class" has been treated as if it related only to the male side of the family line; this is largely because social class has in these studies been measured by occupation. The only further assumption made in the present analysis is that the influence of one's ancestors in determining one's class is transmitted entirely through one's father; so that if the influence of one's father has been taken into account, then the total influence of one's ancestors is accounted for. A more detailed analysis, which explicitly brought in any additional and separate effects of earlier generations and included both sides of the family, would seem to be feasible in principle, though it may well become rather complicated. No attempt at any such generalization is made in this paper.

2. *The Equilibrium Distribution of the Social Classes*

It is convenient to begin by setting out the transition matrix used as the basis for all the subsequent calculations in this paper. This is done in Table 1.§ The jth element of ith row of this matrix, to be denoted by p_{ij}, gives the proportion of fathers in the jth social class whose sons move into the ith social class; alternatively, if it is supposed that there is some unambiguous

* In preparing this paper I have considerably benefitted from discussion with Richard Stone, Director of the Department of Applied Economics, with M. J. Farrell, and with my colleagues at the Department.

† Some evidence on this is given by Glass and Hall in one of the central papers appearing in—Glass (1954), pp. 185–8.

‡ The basis of the approach outlined here is the theory of Markov chains which has applications in a number of fields in the natural sciences. A good account may be found in the work by Feller (1950), especially chapter 15.

§ Taken from Glass and Hall, op. cit., p. 183. The matrix as given here is the transpose of that published by Glass and Hall to conform with the algebraic treatment below.

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method of tracing the family line through time, then p_{ij} represents the probability of a transition by a family from class j into class i in the interval of one generation. In this example

$$i, j = 1, 2, \ldots 7,$$

and a brief description is given at the side of the table of the classes distinguished in this study which are largely on an occupational basis.

TABLE 1

The Social Transition Matrix in England, 1949

[The jth element in the ith row of this table gives the proportion of fathers in the jth social class whose sons are in the ith social class.]

Class	1	2	3	4	5	6	7
1. Professional and high administrative	0·388	0·107	0·035	0·021	0·009	0·000	0·000
2. Managerial and executive	0·146	0·267	0·101	0·039	0·024	0·013	0·008
3. Higher grade supervisory and non-manual	0·202	0·227	0·188	0·112	0·075	0·041	0·036
4. Lower grade supervisory and non-manual	0·062	0·120	0·191	0·212	0·123	0·088	0·083
5. Skilled manual and routine non-manual	0·140	0·206	0·357	0·430	0·473	0·391	0·364
6. Semi-skilled manual	0·047	0·053	0·067	0·124	0·171	0·312	0·235
7. Unskilled manual	0·015	0·020	0·061	0·062	0·125	0·155	0·274

If the table is taken a row at a time, the elements show how the probabilities of entering a given class vary with the class of one's father. Since everyone must be in some class (whatever the class of one's father) it follows that the sum of each column is unity.

Knowing the proportions of fathers in each social group at any time it is possible to derive in an obvious way with the help of this matrix the distribution of the sons among the various social classes. Thus, let s_{it} denote the proportion in the ith social class at time t, then

$$s_{i(t+1)} = \Sigma\, p_{ij}\, s_{jt}; \qquad (1)$$

alternatively, in the more convenient notation of matrix algebra, let s_t denote the (column) vector of the proportions in the various classes at time t, and let P be the transition matrix, then

$$s_{t+1} = P\, s_t. \qquad (2)$$

The unit of time implied in this equation is a generation.

An obvious question now arises: supposing that the matrix P remains unchanged over time, what distribution of the population among the various social classes can be expected at any subsequent period, say, n generations later? Applying the relationship (2) successively, there results

$$s_{t+2} = P s_{t+1} = P(P s_t) = P^2 s_t,$$

$$s_{t+3} = P s_{t+2} = P^3 s_t,$$

and, in general,

$$s_{t+n} = P^n s_t. \qquad (3)$$

This shows the distribution at time $(t + n)$ as dependent on the distribution at time t and on the transition matrix P raised to the nth power.

The interest of the development (3) lies not so much in the detailed relationships for any given period of time but rather in the following general mathematical result which is here stated without proof.* *For any matrix of the kind* P, *the distribution of the social classes tends in time to a value,* $\bar{s}$, *which is independent of the original distribution.* The distribution $\bar{s}$ is here called the equilibrium distribution; it satisfies the equation

$$\bar{s} = P\bar{s} \qquad (4)$$

* A proof of this theorem for a general stochastic matrix will be found in Feller (1950), p. 325.

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and once this distribution is reached it will be maintained through time. The equilibrium distribution so defined thus depends only on the structural propensities of the society and not on the distribution of the population among the classes found at any instant.

The equilibrium distribution is also independent of the unit of time in which the elements of P are measured; suppose, for example, that observations were taken to allow the writing of an equation similar to (1) showing the relationship between the social statuses of grandson and grandfather. Every element of the transition matrix would then be different since it would refer to a transition during a period of two generations instead of one generation. The equilibrium distribution corresponding to such a matrix would however be unchanged. For, if the matrix relating the statuses of sons to fathers is P, that relating those of grandsons to grandfathers will be P^2 (provided, of course, that nothing has happened to change the characteristics of the society in the period considered), and when these matrices are raised to the nth power they obviously tend to the same value as n tends to infinity.

TABLE 2

Actual and Equilibrium Distributions of the Social Classes in England

Class	Actual Distributions of		Equilibrium Distribution (3)	Column (3) / Column (2) (4)
	Fathers (1)	Sons (2)		
1. Professional	0·037	0·029	0·023	0·79
2. Managerial	0·043	0·046	0·042	0·91
3. Higher grade non-manual	0·098	0·094	0·088	0·94
4. Lower grade non-manual	0·148	0·131	0·127	0·97
5. Skilled manual	0·432	0·409	0·409	1·00
6. Semi-skilled manual	0·131	0·170	0·182	1·07
7. Unskilled manual	0·111	0·121	0·129	1·07

Table 2 gives the actual distribution of the classes, as estimated from the sample of observations, for the sons and for the fathers, together with the equilibrium solution. On the whole it will be seen that the distributions are remarkably similar, and hence that even if the transition matrix of Table 1 continues to hold entirely unchanged over the next few generations, no great changes are to be expected in the distribution of the population among the various social classes.

A more precise comparison of the results is made in the last column of the above table which shows the ratio of the proportion of the current generation, that is of the sons, in each class to the proportion to be expected in equilibrium. These figures are very regular and indicate that if recruitment to the various classes proceeds as it has in the past generation then the proportion in the uppermost class will decline by about a fifth, while the proportions in the two lowest classes will rise somewhat.

Since the definition of social class which was used in compiling these figures is based largely on occupation there are obvious qualifications to the validity of the last conclusions, though these would not seem to detract from the interest of this kind of calculation. However, my friend Mr. M. J. Farrell has suggested to me that when there are considerable differences between the observed distributions of fathers and sons it is more reasonable to suppose that these are for the greater part due to once-for-all shifts in the distribution of the various kinds of occupations made available by the industrial system. When this is so it is desirable to make what amendments one can to the observed transition matrix before proceeding with the calculations suggested in the following sections. A method of making such adjustments is suggested in Appendix A, and the same formal method can be used for correcting the matrix for differences in the net reproduction rates of the various classes. Since in the case examined here the differences between the distributions of the two observed generations are not very great, adjustments of this sort are not considered in the main text.

3. *The Average Time Spent in a Social Class*

In this section the transition matrix is interpreted on the basis of the supposition, mentioned above, that there is an unambiguous method of tracing a family line through time. No funda-

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mental distinction is drawn between intra-generation mobility and inter-generation mobility, but these are both regarded as referring to the same phenomena and are to be described by similar sets of data; the only difference between these concepts is the period of time to which the phenomena relate. Problems arising in the latter connexion can be treated more satisfactorily along the lines to be suggested in the following section.

If there were a complete absence of mobility in a society each family line would stay in its social class for a theoretically infinite period of time; on the other hand, the more mobile the society the shorter the period during which a particular family line would be found in a given social class. The average period spent in a social class, as compared with the period spent in that class in a comparable but perfectly mobile society, would seem to provide a measure (but, of course, not the only measure) of the mobility of a given society.

The average number of generations spent in a social class is most simply calculated as follows. Let there be s_j families in class j in the current generation. Of these the number $s_j p_{jj}$ will be found in the jth class in the next generation; the number $s_j p_{jj}^2$ will be found in the third generation, and so on. Hence the total time spent in the jth class by the s_j families at present in that class is

$$s_j + s_j p_{jj} + s_j p_{jj}^2 + \ldots$$

On dividing by s_j there results the average time, t_j, spent by a family in that class; thus

$$t_j = 1 + p_{jj} + p_{jj}^2 + \ldots$$

that is,

$$t_j = \frac{1}{1 - p_{jj}}. \qquad (5)$$

An alternative approach with the help of which it is possible to obtain also the standard deviation of the time spent in each social class is given in Appendix B. It is there shown that the standard deviation is

$$\sigma_j = \frac{\sqrt{p_{jj}}}{1 - p_{jj}}. \qquad (6)$$

In order to use the measures t_j in assessments of the mobility of a society it is necessary to know what would be the corresponding values of these measures in a society that is perfectly mobile. This must now be defined.

In terms of the transition matrix, a perfectly mobile society is a society in which the probability of entering a particular social class is independent of the class of one's father; so that all the elements in each row of the matrix would be substantially equal (to any given degree of approximation), though there would generally be differences between the rows. A more general definition of perfect mobility would make the probability on entering a class substantially independent of that of one's n^{th} progenitor; where the first progenitor is defined as the father, the second progenitor as the grandfather, and so on. Just how small the value of n, and how small the differences between the elements in any row, should be before the society is judged as adequately mobile are questions of social policy from which a discussion of this sort must abstract as far as possible; some calculations which bear on this are, however, given in the next section.

Of the infinitely many possible perfectly mobile societies, the one chosen here as a basis for comparison with our actual society is that which has the same equilibrium distribution of the social classes. Hence the transition matrix of the perfectly mobile society which is comparable to our own, is composed of the values given in column (3) of Table 2; it will be a matrix which has that column repeated seven times. Since the equilibrium distribution depends on the broadness of the definition of each class, it will be apparent that by making a comparison with it, the measures t_j are standardized for these differences in the broadness of the classes. Values of t_j for different classes therefore become directly comparable.

If there were other information available on long term trends in the occupational distribution of society it may be preferable to use some other distribution in place of the equilibrium distribution suggested here. For example, if it were thought that the present distribution between the classes was likely to continue unchanged over the next few generations (and that if anything had

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to change it would be the transition matrix that would change in order to conform to such a distribution) then it would be more sensible to use as a basis for comparison a transition matrix of a perfectly mobile society which led to such a distribution. The course adopted here is thought preferable since it makes use of what knowledge there is available (in the matrix) of the latent tendencies of society.*

The results of the calculations based on the formulæ given above are set out in Table 3. The first column shows that even when only seven groups are distinguished in the population, in no case does the average number of generations spent by a family in a particular social class exceed

TABLE 3

The Average Number of Generations Spent in Each Social Class in England To-day and in a Similar but Perfectly Mobile Society

Class	Average Number of Generations in: England To-day (1)	Average Number of Generations in: Mobile Society (2)	Column (1) / Column (2) (3)	Standard Deviation of Col. (1) (4)
1. Professional	1·63	1·02	1·59	1·02
2. Managerial	1·36	1·04	1·30	0·71
3. Higher grade non-manual	1·23	1·10	1·12	0·54
4. Lower grade non-manual	1·27	1·15	1·11	0·58
5. Skilled manual	1·90	1·69	1·12	1·30
6. Semi-skilled manual	1·45	1·22	1·19	0·81
7. Unskilled manual	1·38	1·15	1·20	0·72

two. The longest time is 1·9 generations for the skilled manual and routine non-manual workers, which is the broadest of the groups distinguished. The impression that families may spend longer than this in a particular class is no doubt due to the wide dispersion of the actual times†; as will be seen from column (4) of the table, the standard deviations are in fact considerable.

The second column of the table shows the average number of generations that would be spent in each class if the society were perfectly mobile. The least time, 1·02 generations, would be spent in the top group of professional and high administrative workers, which is the smallest group; whereas 1·69 generations is the average time for the broadest group.

The measures of the immobility of the social structure are given in column (3). It will be seen that the bottom five groups are affected approximately equally by the effects of immobility; the net result being that the average family spends between 10 and 20 per cent. more time in these social classes than if society were completely mobile. Values as low as this may be considered as negligible in view of the biases to which these figures may be subject.‡

However, in the top group the effects of self-recruitment are such as to raise the time spent by some 60 per cent. over that in a perfectly mobile society; and this figure may well seem excessive when compared with the others. For the second group from the top the excess time is somewhat lower at 30 per cent.

4. *The Variation of Mobility with Time*

The measure of mobility given in the last section is of a particularly simple sort since it depends only on the amount of self-recruitment in each class—that is, on the diagonal elements of the transition matrix. The other elements only enter into the calculation of the equilibrium distribution which is used as a standardizing factor.

* The alternative calculations given in Appendix A assume that there is no difference between the present and the equilibrium distributions; so that if it were thought that the present distribution will continue to hold these alternative calculations are to be preferred.

† Another reason may be that when thinking in terms of social classes in this connexion, it is not convenient to distinguish as many as seven classes and, of course, the broader the grouping of the classes the longer is the time spent in any class. Thus, if Classes 3, 4 and 5 are grouped into one large "middle class", it is found that the average time spent by a family line in that class is 3·3 generations.

‡ The principal bias is that at the time of questioning the subject may not have reached his final status, so that the full amount of movement between generations is understated.

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In this section a set of rather more complicated measures is proposed which have the advantage that it is possible to assess with their aid the amount of movement among the various social classes achieved in successive generations; these measures depend more directly on all the elements of the matrix. They arise from the observation that in societies such as those described by Table 1 not only is the degree of self-recruitment higher than in a perfectly mobile society, but also the degree of recruitment from adjacent classes is higher than that from the more distant classes.

Since it is also true that the probability of moving into adjacent classes is higher than that for movements into the more distant classes, the net result is that if we consider, say, the number of grandfathers whose sons have moved out of their social class but whose grandsons have moved back into that same social class, then this number will also tend to be higher* than that to be found in a perfectly mobile society.

An example may make this clearer. Referring to Table 1 it will be seen that the probability of moving from Class 1 to Class 2 in the first generation, and then back into Class 1 in the second generation, is given by the value $0{\cdot}146 \times 0{\cdot}107 = 0{\cdot}016$. On the other hand, the probability of moving from Class 1 to the more distant Class 5 and back again is given by the much smaller value of $0{\cdot}140 \times 0{\cdot}009 = 0{\cdot}001$. In the similar but perfectly mobile society (based on the equilibrium values given in Table 2) the value of these probabilities would be, respectively, $0{\cdot}042 \times 0{\cdot}023 = 0{\cdot}001$, and $0{\cdot}409 \times 0{\cdot}023 = 0{\cdot}009$. So that for this society the probability of moving into an adjacent class and back is higher than that in a perfectly mobile society, while for a distant class it is smaller.

The net effect—that is, the probability of moving into any other class from the first class and then back into the first class—may be found by summing over the six classes and will be found to have the value $0{\cdot}025$, as compared with the value of $0{\cdot}022$ to be found in perfectly mobile society. If the probability of self-recruitment is included in these figures, as is especially convenient when these measures are generalized to n generations, there results the probability of finding one's grandson in one's own class irrespective of whether one's son has remained in the same class or not. The values obtained for the first class in the actual and perfectly mobile society are then $0{\cdot}176$ and $0{\cdot}023$. The ratio of these two figures is $7{\cdot}6$ and may be termed the Immobility Factor for the second generation relating to the first class: it shows that for this class there are nearly eight times as many grandsons in one's own class than there would be in perfectly mobile society.

The generalization to great-grandsons, great-great-grandsons and so on, to yield Immobility Factors for the third generation, fourth generation and so on, is now straightforward. The possibility of doing this is considerably simplified by the following theorem which holds for any perfectly mobile society.

Suppose that the number of family lines in the jth class were enumerated now and, after an interval of n generations, they were enumerated again. At the second enumeration it would be found that a certain proportion, say $m_{jj}^{(n)}$, of those family lines originally in the jth class were still in that class. The theorem states that in a perfectly mobile society this proportion does not depend on the number of intervening generations; that is $m_{jj}^{(n)}$ is independent of n.

The proof of this proposition, if any is needed, is simple. For the proportions $m_{jj}^{(n)}$ are the elements of a matrix M^n defined by an equation analogous to (3). Now, if M is the transition matrix of any perfectly mobile society that is, for all i and k it is true that $m_{ik} = m_{ii}$, then the elements of M^2 are given by

$$\begin{aligned} m_{ij}^{(2)} &= \sum_k m_{ik} m_{kj} = \sum_k m_{ii} m_{kj} \\ &= m_{ii} \sum_k m_{kj} \\ &= m_{ii} \end{aligned}$$

since the sum of any column is unity. Hence

$$M = M^2 = M^3 = \dots, \qquad (7)$$

and, in particular, $m_{jj} = m_{jj}^{(n)}$.

On the other hand, in a society that is at all immobile, the ratio of family lines to be found in the jth class now to those who were originally in that class n generations ago (and have either stayed

* In general it will only be different: if the amount of self-recruitment is particularly high the number will be *less* than that in a perfectly mobile society.

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in that class for the intervening n generations or have left that class and returned to it) will depend on the value of n (so long as n is finite). The ratios will in fact be given by the diagonal elements, $p_{jj}^{(n)}$, of the matrix P^n defined in equation (3) above.

TABLE 4

Immobility Ratios for the First to the Fourth Generations in England

Class	*First*	*Second*	*Third*	*Fourth*
1. Professional	16·9	7·6	4·0	2·4
2. Managerial	6·4	2·9	1·8	1·4
3. Higher grade non-manual . .	2·1	1·3	1·1	1·1
4. Lower grade non-manual . .	1·7	1·1	1·0	1·0
5. Skilled manual	1·2	1·0	1·0	1·0
6. Semi-skilled manual . . .	1·7	1·2	1·1	1·0
7. Unskilled	2·1	1·3	1·1	1·0

The measures of immobility for the tth generation are then defined as $p_{jj}^{(t)}/m_{jj}$. The following points are worth noting.

First, for $t = 1$, this measure has a direct relationship with the measure based on the average time spent in each class which was considered in the last section. However, it is not possible from a knowledge of one of these measures alone to obtain the other.

Secondly, as t becomes larger, the Immobility Ratios for all classes tend to unity, indicating that after a sufficiently long time the number of descendants to be found in one's own class differs arbitrarily little from that to be found in a perfectly mobile society.

Thirdly, the Immobility Ratios for the first generation are almost* identical to the Indexes of Association used in the studies edited by Glass. The ratios for the tth generation proposed here may therefore be regarded as generalization of this measure.

Fourthly—and this is perhaps the main interest of this set of ratios—suppose that on the basis of external considerations a perfectly mobile society was defined as one in which the chance of entering a particular class could depend on one's father's class but would be independent of one's grandfather's class. Then the Immobility Ratio for the second generation would give a correct measure of the deviation of the social structure from this ideal; and the ratios for this and all the subsequent generations would still be valid as measures of the progression of mobility through time. In general, if in the perfectly mobile society the probability of entering a class is defined as being independent of one's t^{th} progenitor, this requires that only the Immobility Ratios for the tth generation and onwards be considered, but the calculations do not have to be modified in any way.

Immobility Ratios for the first four generations have been calculated from the data given in Table 1 and the results are brought together in Table 4. They show that in the first generation there is a fair amount of immobility: the largest index is that for the first group of professionals and high administrators, and the lowest value is that for the fifth group where there is a negligible amount even of first generation immobility.

By the time the third generation is reached all the classes except the upper two may be judged to be fully mobile for practical purposes. The Index shows, however, that the first class has four times as many great-grandsons in its own group than would be found in a perfectly mobile society. Even by the time the fourth generation is reached, the index for this class is still higher than that for the five lower classes in the first generation.

The impression to be gained from this table as to the extent of social immobility, and its importance as a factor in social policy, may at first sight be rather different from that gained from the previous table from which it appeared that, on the average, the time spent in any social class did not exceed two generations. It is, therefore, worth adding that the two sets of measures are entirely consistent. The impression of a greater degree of immobility which may be derived from the calculations of this section is due to the fact that they are not based merely on the average values of the distribution : though Table 4 shows that there are four times as many of one's own descendants to be found in the first class in the third generation than there would be in a perfectly

* The sole difference is that the equilibrium distribution is here used to standardize the ratio instead of the actual distribution of sons used by Glass and others.

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mobile society, the absolute numbers involved are very small and this value therefore received only a small weight in calculating the average number of generations spent in that class.

5. *Some Extensions*

The main implications to be drawn from a probability approach to the theory of social mobility have been set out in the previous sections. In this section there are outlined two extensions to the formal framework and some remarks are added on possible further work.

The first extension is an implication of the basic theorem mentioned in section 2 that the equilibrium distribution is independent of any initial distribution, s_t. This theorem implies at once that the probability of being in the jth class n generations after being in the ith class tends to a value, as n increases, which is independent of i; that is

$$p_{ji}^{(n)} \to \bar{s}_j. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

This merely assures us that our formal system has the commonsense property that the probability of being in a particular class is independent of the class of one's ancestor, say, a thousand years ago.

Secondly, any distribution, s_t, may be viewed either as giving the proportions in the various classes in which it is to be expected that a large population will be found at time t; or as giving the probabilities that any particular family line will be found in any of the social classes at that time. From the latter point of view, the equilibrium distribution similarly gives the probabilities that any particular family line will be found in any of the social classes at all times (except possibly for a first few generations).

Since any particular family line will throughout history spend its time wandering from one social class to another, it is possible to compute the average time between its returns to any particular class, or the *mean recurrence times*. These are equal to the reciprocals of the elements, $\bar{s}_j$, of the equilibrium vector.*

Calculations based on the equilibrium values given in Table 2 show that the mean recurrence time varies between 2·4 generations for the fifth class of skilled manual workers† to a maximum of 41·6 generations for the top class of professional workers. It will be obvious from what has been said in earlier sections that these values are entirely determined by the broadness of definition of the various social classes and hence do not directly cast any light on the extent of social mobility. But these measures may be of help as another way of assessing the broadness of the classes.

It would obviously be valuable to carry out comparable computations of the average time spent in each social class (and the other measures proposed here) both for this country at various past times, and for other countries for which comparable data are available. When this is done it will become rather more important to face a problem that has been avoided in this paper as requiring separate treatment: that of the assessment of the statistical errors in the estimation of the transition matrix and in its various transformations.

The problems that arise under this head do not appear to be very serious since the classical formula for the variance of a proportion, $p(1-p)/n$, where n is the number of observations, can be applied in a fairly straightforward way in estimating the variances of the elements of the transition matrix. Some mild problems will, however, have to be solved in obtaining confidence limits for the derived summary measures proposed in this paper.

References

FELLER, W. (1950), *An Introduction to Probability Theory and its Applications*. New York: Wiley. London: Chapman & Hall.

GINSBERG, M. (1929), "Interchange between social classes", *Economic Journal*, 39, 554–565.

GLASS, D. V. (1954), Editor, *Social Mobility in Britain*. Routledge & Kegan Paul.

* An intuitive proof of this may be found helpful. If the probability of obtaining a 1 with a balanced die is 1/6th, a little reflexion or experimentation should convince the reader that the mean recurrence time between throws of a 1 will be six. Consider next the probability of throwing a 1 or a 2; this will be 1/3rd and on the average it will be necessary to wait for three throws before either a 1 or a 2 appears. Similarly, if $\bar{s}_j$ is the probability of being in class j at any time through history, the mean time between recurrence in j will be $1/\bar{s}_j$ as stated. The rigorous proof is rather more difficult and is given in Feller (1950), pp. 259–61.

† This is presumably the basis of the popular saying "From clogs to clogs—three generations".

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APPENDIX A

*A Correction for Shifts in the Occupational Structure**

The differences between the observed distributions of sons and fathers have, in the main part of the text, been attributed entirely to the results of the forces making for social mobility as represented in the transition matrix. The alternative assumption to be investigated here is that, if the effects of social mobility alone were observed, there would be no differences between the proportions of sons and fathers in each class. What differences there are should be ascribed to extraneous factors such as shifts in the occupational structure or differences in the reproduction rates of the classes. This alternative assumption is at the other extreme from that made in the main part of the text and a comparison of the two sets of calculations should provide limits for the true state of affairs.

The observed transition matrix P can then be considered as the resultant of the effects of social mobility, represented in a matrix Q, and the effects of occupational shifts represented in a matrix R, such that

$$P = Q\,R. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

A simple assumption to make in estimating the elements of R is to suppose that the numbers in any class after the change in the occupational structure are composed of a weighted average of those in that class and in one of the adjacent classes before the change. The adjacent class should be chosen as the one† above or below so as to make both weights positive. There will generally be a unique way of doing this, and this is illustrated in Table 5 which is constructed as follows.

TABLE 5

Changes in the Occupational Structure of England in the Last Generation

Class	1	2	3	4	5	6	7	Σs_{t+1}
1	103	—	—	—	—	—	—	103
2	26	133	—	—	—	—	—	159
3	—	17	313	—	—	—	—	330
4	—	—	32	427	—	—	—	459
5	—	—	—	91	1,338	—	—	1,429
6	—	—	—	—	172	421	—	593
7	—	—	—	—	—	37	387	424
Σs_t	129	150	345	518	1,510	458	387	3,497

The actual distribution of the fathers, based on the sample figures, is written down in the bottom row and the distribution of the sons, which is to be derived from this, is written down in the extreme right-hand column. Since there are 129 fathers in the first class and only 103 sons in that class, it is assumed that the balance of 26 sons has moved into the second class. The number 103 is therefore written in the leading position and the number 26 below it. The remaining 133 sons, which are required in the second class to give the observed total of 159, are then taken from the 150 fathers in that class so leaving a balance of 17 to be carried forward to the third-class. This procedure is continued till the final class is reached which balances out exactly, since the number of sons and fathers is equal in total.

The matrix R is then derived by dividing each column by the sum of the elements in it, and this matrix will then satisfy the equation.

$$s_{t+1} = Rs_t. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

‡ Of course, if there were any more direct information available on the way any particular factor affected recruitment to the various classes, it should be incorporated into the definition of R.

* I owe the substance of this Appendix to some illuminating conversations with my friend Mr. M. J. Farrell.

† If the differences between the observed distributions are very great it may be necessary to choose more than one class; this follows from the method outlined in the following paragraph.

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The calculation of Q then requires that R be inverted, and this is not too difficult on account of the large number of zeros contained in the matrix. From (9), it follows that Q is given by PR^{-1}.

Since it is still true that

$$s_{t+1} = Ps_t = QRs_t$$

it follows on substituting from (10) that

$$s_{t+1} = Q\,s_{t+1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

so that s_{t+1} is the equilibrium distribution corresponding to the corrected social mobility matrix Q.

Calculations along the above lines have been carried out on the data examined in the main text. The values found for the matrix Q are set out in Table 6, and the derived measures of the average time spent in each social class (comparable with Table 3 above) are given in Table 7.

TABLE 6

The Social Transition Matrix Adjusted for Shifts in the Occupational Structure

Class	1	2	3	4	5	6	7
1. Professional	0·457	0·116	0·036	0·023	0·010	0·000	0·000
2. Managerial	0·110	0·287	0·107	0·042	0·025	0·013	0·008
3. Higher grade non-manual . .	0·195	0·231	0·195	0·119	0·079	0·041	0·036
4. Lower grade non-manual . .	0·050	0·111	0·187	0·230	0·127	0·088	0·083
5. Skilled manual . . .	0·128	0·187	0·351	0·419	0·483	0·393	0·364
6. Semi-skilled manual . . .	0·046	0·052	0·062	0·118	0·152	0·319	0·235
7. Unskilled	0·015	0·015	0·062	0·049	0·122	0·144	0·274

It will be seen that the calculations are in fact rather insensitive to occupational shifts of the order of magnitude dealt with here.

TABLE 7

The Average Number of Generations Spent in Each Social Class in England and in a Perfectly Mobile Society.
[Adjusted for Shifts in the Occupational Structure]

Class	*Average Number of Generations in*		
	England (1)	*Mobile Society* (2)	*Column (1) / Column (2)* (3)
1. Professional	1·84	1·03	1·79
2. Managerial	1·40	1·05	1·33
3. Higher grade non-manual . . .	1·24	1·10	1·13
4. Lower grade non-manual . . .	1·30	1·15	1·13
5. Skilled manual	1·94	1·69	1·14
6. Semi-skilled manual	1·47	1·20	1·22
7. Unskilled	1·38	1·14	1·21

The largest change is in the figure of the average number of generations spent in the top class, which is here raised to 1·84 from its previous value of 1·63, and thus suggests that the amount of immobility is slightly higher than has been suggested in the main part of the text.

APPENDIX B

The Mean and Variance of the Times Spent in a Social Class

Let p_{jj}, or for short p, be the probability that a father who is now in class j will have his son also in class j.

Then $(1 - p)$ is the probability that the son will leave that class, and therefore also the expected proportion who stay in that class for one, and not more than one, generation.

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Of the proportion p who stay into the second generation, the proportion p^2 will stay on to a third generation, and proportion $p(1-p)$ will leave at the end of the generation and thus will have stayed for exactly two generations.

In general, the proportion which stays exactly r generations can thus be seen to be $p^{r-1}(1-p)$.

Since everyone stays for exactly 1, or 2, or 3, ... generations, it follows that the sum of the proportions is unity; this can easily be seen, for

$$(1-p) + p(1-p) + p^2(1-p) + \ldots = 1$$

The average time spent can be found by weighting these proportions with the time spent, thus

$$\begin{aligned} E\{t\} &= \sum_1^\infty r\,p^{r-1}(1-p) = (1-p) + 2p(1-p) + 3p^2(1-p) + \ldots \\ &= 1 + p + p^2 + \ldots \\ &= 1/(1-p) \end{aligned}$$

which is the result already found in the main text on the basis of a simpler argument.

The variance of the time spent can be found as follows. First, find the mean square of the time,

$$\begin{aligned} E\{t^2\} &= \sum_1^\infty r^2\,p^{r-1}(1-p) = (1-p) + 4\,p(1-p) + 9\,p^2(1-p) + \ldots \\ &= 1 + 3p + 5p^2 + 7p^3 + \ldots \\ &= (1 + p + p^2 + p^3 + \ldots) + 2p(1 + 2p + 3p^2 + \ldots). \end{aligned}$$

Now, the terms in the second set of brackets are the derivatives of the terms in the first set of brackets; the sum of the second set is therefore the derivative of the sum of the first set. Hence,

$$E\{t^2\} = \frac{1}{1-p} + \frac{2p}{(1-p)^2}$$

To find the variance it is only necessary to subtract from this, in the usual way, the square of the mean time, and this gives

$$\begin{aligned} V\{t\} &= \frac{1}{1-p} + \frac{2p}{(1-p)^2} - \frac{1}{(1-p)^2}. \\ &= \frac{p}{(1-p)^2}. \end{aligned}$$

The standard deviation of the times is the square-root of this expression which has been given as (6) in the text.

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The Sources and Nature of Statistical Information in Special Fields of Statistics

Statistics Bearing on Financial Investment

By J. I. Mason and D. Sachs

Contents

	PAGE
Introduction	
1. General Indicators of Stock Exchange Investment Activity	67
(a) Stock Exchange Markings	68
(b) The Security Price Recording Organization	69
(c) The *Financial Times* Series of Share Indices	70
(d) The Actuaries' Investment Index	73
(e) Moody's Indices	74
(f) *Investor's Chronicle* Indices	76
(g) *The Bankers' Magazine* Securities Values Index	77
(h) A Note on Security Indices Generally	77
(i) The Annual Stock Exchange Valuation of Securities	78
(j) Government Published Data on Trading Profits and Dividends	83
(k) National Debt and Related Data	84
2. Financial Analyses of an Industrial Character	84
(a) The *Financial Times* "Trend of Industrial Profits" Analyses	84
(b) The *Economist* Quarterly Profit Analyses	85
(c) The "Inland Revenue" Analysis	87
(d) Miscellaneous Sampling Inquiries	89
(e) Commodity Price Indices	90
3. Statistics of Individual Concerns or Special Groups	91
(a) Historical Records	91
(b) Latest Current Records	92
4. Broad Economic Data Concerning Companies; Investment Holdings; Personal Savings, etc.	92
(a) The Number of Limited Liability Companies and their Nominal Capital	92
(b) The Number of Private Investors	93
(c) Investments held by Various Institutions	94
(d) Distribution of Savings in Private Hands	95
(e) The Overseas Investments of U.K. Residents	97
(f) A Note on New Capital Issues	97
5. Gaps and Projected Research	97
Text-references and Additional Bibliographical Information	98

Introduction

Those making business investments, or advising others in the proper use of funds, while exercising a high degree of personal judgment when making decisions, must also study whatever sound relevant economic information is procurable.

Analysis of what statistical material is available may perhaps convince the reader that the amount directly or specifically of value for any particular business purpose is exceptionally limited. The amount available to provide general impressions, and an occasional specific "straw in the wind" is, however, embarrassingly large, and might be thought to require the combined powers of an Argus and a clairvoyant. Skill in use must derive primarily from experience, and preoccupation with business affairs, rather than from the direct application of such statistical material itself.

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The choice, therefore, before the compilers of this summary has lain somewhere between (i) covering merely the few general statistics of activity on the Stock Exchange and (ii) covering the whole range of statistics, official and unofficial, bearing on finance, industrial trends, commodity prices at home and abroad, purchasing power, and so on, which are, for specific investment purposes, intricately interlocked.

Fortunately, papers already published, or to be published, cover many parts of the latter extended field. This study, therefore, attempts merely to stop gaps not likely to be filled elsewhere, and to give a brief perspective of what is available having some direct bearing on the study of investment in securities quoted on the Stock Exchanges (and especially the London Stock Exchange).

No "index" in the financial field can ever serve as more than an "indicator". The investment adviser can, and often does, profitably study also:

the apparent trends in long and short term rates of interest, at home and abroad;

evidence or impressions regarding the money flow, from such material as Note Circulation, Bank Advances, Provincial Clearings, National Savings, Revenue Returns, new money arising in the "institutions" and other collectors of savings;

evidence regarding the total amount, actual and pending—and the nature—of New Capital Issues; impressions of the trends of liquidation and bankruptcy;

the general state of trade and purchasing power, as shown by facts and figures on prices, wages, production, consumption, income and taxation, balances of payments, etc., nationally and internationally.

Reference to certain "New Capital" statistics is made in the Appendix, but otherwise no attempt is made to itemize sources in that wide field.

The limited field selected for study can be loosely defined as that containing the following four main types of statistical data.

(i) *General Stock Exchange Activity "Indicators"*

(Broad indicators of security activity derivable from the Stock Exchanges, financial papers, professional associations, Government sources, etc.)

(ii) *Analyses of Companies by Broad Industrial Group, etc.*

(iii) *Miscellaneous Company Information*

(Less general material, covering specific groups of businesses, or individual companies.)

(iv) *Data Throwing Some Light on the General Structure of Companies, Business and Personal Investment*

(Sources of data relating to the number of companies and their nominal capital; estimates of the number of investors; the distribution of investment holdings; estimates of private wealth and its distribution; private savings; etc.)

1. General Indicators of Stock Exchange Investments Activity

1 (a) *Stock Exchange "Markings"*

(i) The London Stock Exchange records each day, in its *Daily Official List*,(1) a total of "marks received", with sub-totals for each group of securities, forming the various "markets", contained therein; together with a total for securities listed in the *Monthly Supplement*. The range of prices quoted and the prices at which "bargains" were marked are also shown for each. Some recent figures of "marks received" are shown in Table 1.

Owing to the method of recording "marks", no data are procurable, however, regarding the actual number of shares or stock units, or the value turned over. A "mark" merely records that a "bargain" has been made; the slip of paper, voluntarily sent in for tabulation, shows only the name of the security and the price involved in the transaction. Thus only a personal and expert knowledge of the day's working conditions can help to assess changes in the monetary volume of buying and selling; due allowance has to be made for political and business sentiment and the position in the "account" cycle of the day of dealing.

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The total "marks" received daily are reported each week in the financial press while averages for various groups serve as the base for various indicators of "activity" (see 1 (f)).

Details of total marks received for the year ending March 24th are published annually by the London Stock Exchange.(2)

TABLE 1

Average Daily Markings on the London Stock Exchange (00's)

In	*1948*	*1949*	*1950*	*1951*	*1952*	*1953*	*1954*
January	105	69	61	91	75	73	107
February	94	66	59	123	79	78	116
March	76	65	60	98	67	83	108
April	82	61	64	111	70	79	116
May	86	62	65	100	63	68	118
June	74	60	72	90	57	62	112
July	59	58	60	80	62	70	125
August	54	53	60	64	64	73	136
September	60	70	80	78	63	82	135
October	68	76	84	87	65	94	140
November	70	62	94	78	69	99	137
December	59	56	62	65	58	79	103
For the Year	74	63	69	89	66	79	121
Number of business days	256	253	254	255	255	254	256

(ii) Before 1940 the statistics related only to marks *recorded.* From 1939 onwards, however, all marks *received* were totalled. Up to June, 1943, it was customary to record only three bargains made on the same date at the same price in any one security in the Daily List, and only two bargains similarly for those on the Supplementary List. It is of some interest to study the relationship of the two series, although the years naturally were of an abnormal character, to see what type of adjustment may have to be made subjectively to pre-war figures of marks *recorded* if stricter comparisons are required. From January, 1939, to March, 1942, marks *recorded* represented some 80 per cent. of marks *received* in the Daily List and some 90 per cent. of those in the Supplementary List. Since June, 1942, marks received have been published, but only one mark is recorded for any one security at any one price. In 1943–7 the percentage of marks received represented by marks recorded was approximately 50 per cent. for those in the Daily List, and 60 per cent. for those in the Supplementary List. From April, 1947, to March, 1952, the combined percentage remained approximately 54 per cent. of total.

Data on "markings" in post-war years for each "market" group have been given with the Annual Valuation Statistics (see 1 (i)) but still provide only an aggregate for those in the "Monthly Supplement".

TABLE 2

Marks Recorded *for Stock Exchange Years Prior to* 1940
(000's)

	Daily List	Supplementary List
Year to March 24th 1934	1591	676
" " " " 1935	1470	780
" " " " 1936	1552	793
" " " " 1937	1635	1008
" " " " 1938	1275	663
" " " " 1939	1151	518

1 (b). *The Security Price Recording Organization*

A "free" market, whether in securities or commodities, requires a wide and speedy dissemination of financial information. In securities, a jobber quotes a buying and selling price. The average of these two is that usually reported; the "range" or divergence from the average of the two prices differs widely, however, between the various markets and in changing conditions, i.e. a

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quotation may be "wide" or "close" according to the margin or spread between bid and offered prices.

At all times, knowledge of current and indeed, up-to-the-second, prices or quotations are available on the "floor" of the Exchange to brokers or their clerks, so that prices are being passed from person to person continuously. Constant telephone connection between the brokers' offices and the clerks on the "floor" is provided, near the "floor", by (*a*) direct P.O. lines and (*b*) by the Exchange Telegraph Company through its special branch exchange system, which provides intercommunication between all members and their clerks.

Thus, apart from any extraneous organized system of price reporting, the Stock Exchange in London carries on its own internal methods of price reporting. Private lines, under certain conditions, convey this information to various provincial Stock Exchanges. Printed details of security prices are in many cases produced by the larger Stock Exchange firms in respect of the shares in which they specialize, for distribution to their own clients and for other uses inside the House.

The Exchange Telegraph's reporting services were instituted in the early 1870's. Reporters with long and expert experience of market conditions, obtain from representative jobbers their latest quotations of the shares in which they specialize. More than 100 jobbers are thus regularly visited at intervals throughout the day, and sectional lists of their shares are obtained indicating current prices. These prices are then "taped". There is necessarily a lag between the actual currency of the latest quotation and its appearance on the tape-printers employed to convey the information to a large body of brokers' offices, and other groups of interested people. The supply of the information to the latter categories is subject to the special approval of the Council of the Stock Exchange itself.

The information appearing on the E.T.C. tape is based on information supplied by jobbers themselves and thus represents the conditions "at the time of asking". It does not represent actual business in any security and as the marking of bargains is not compulsory in most cases, a "quotation" cannot be tied down to any individual dealing. This system is quite different, therefore, from that obtaining in New York and Toronto, where very fast tape printers record the actual bargains in any security together with the number of shares changing hands.

The lower and upper quotations given in the Stock Exchange *Daily Official List* are collected from the jobbers by the marking board officials of the Stock Exchange near the close, and are used, *inter alia*, for legal or probate purposes. As marking is not compulsory, except in a few special cases, the printed record does not completely record business done in the "House", while, as previously mentioned, bargains at the same price are not separately shown.

The more important newspapers, and in particular the technical press, maintain a special corps of reporters and commentators of their own, using the E.T.C. financial tape as a background. These press reporters have a number of special contacts with "House" people who supply at the end of the day the latest prices in the more active shares and also information of conditions and trends. In recent years the E.T.C. has found it necessary to supply a service specially prepared for newspapers which is more comprehensive than the tape service supplied to brokers, and includes as well, reports on trends and conditions in the "House" trading and details of the principal rises and falls at various times during the day and various commodity and money market and exchange rate news. Jointly with the Press Association, the E.T.C. compiles and supplies a number of provincial morning and evening newspapers with reports and price changes.

Company financial results, and other information in respect of managerial or directorial changes of policy are, under the Stock Exchange dealing rules, supplied to the Share and Loan Department of the Stock Exchange, which posts the statements on various strategically placed boards on the floor of the "House". This information is also disseminated on the financial tapes.

1. (c) *The* Financial Times *Series of Share Indices*

The compiling of indices of general movements in security prices is not attempted by the London Stock Exchange itself. Prices, etc., circulated as in 1 (b) are assembled through various agencies, etc., in ways considered most suitable for their various clientele or readership.

The Financial Times newspaper has provided such a service for many years. Indices for Government Securities and Gold Mines go back, on a daily basis, as far as 1926; from 1928 fixed interest securities were included; from 1935, industrial shares

All the indices are based on the middle "closing" prices, but all except Gold Mines are

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unweighted. Monthly averages have been assembled and published since 1947. These represent the straight arithmetic averages of the indices available for the varying number of business days recorded, and are shown in Table 3 at quarterly intervals. Table 4 provides comparative details monthly for 1953 and 1954.

TABLE 3

Trends in Financial Times *Shares Indices*

No. of Securities	*Government Securities (11)*		*Fixed Interest (20)*		*Industrial Ordinary (30)*		*Gold Mines (30)*	
	High	*Low*	*High*	*Low*	*High*	*Low*	*High*	*Low*
January, 1947	121	120	150	149	141	134	135	129
April	118	117	144	142	135	129	125	119
July	117	113	143	136	135	120	119	113
	Monthly Averages		*Monthly Averages*		*Monthly Averages*		*Monthly Averages*	
October	114		134		114		125	
January, 1948	113		134		125		124	
April	112		131		119		130	
July	112		132		111		111	
October	113		133		118		105	
January, 1949	114		134		122		90	
April	114		134		115		104	
July	109		127		104		109	
October	106		122		103		134	
January, 1950	105		121		105		131	
April	105		121		107		131	
July	106		122		111		110	
October	109		124		117		114	
January, 1951	107		123		119		114	
April	104		118		127		122	
July	102		116		134		110	
October	102		116		136		113	
January, 1952	96		106		117		99	
April	94		105		112		93	
July	91		102		109		95	
October	94		105		115		91	
January, 1953	95		106		118		95	
April	97		108		121		96	
July	97		109		120		88	
October	100		111		128		83	
January, 1954	100		112		133		91	
April	102		113		144		91	
July	105		116		159		87	
October	106		117		176		95	

Composition of the Financial Times *Stock and Share Indices as at January 1st, 1955*

Government Stocks

Consolidated 2½%
Consolidated 4% (1957 or after)
Conversion Loan 3½% (1961 or after)
Funding Loan 4% (1960–90)
Victory 4%
Treasury 2½% (1975 or after)

Fixed Interest Index (20)

British Corporations

London County 2¾% (1960–70)
Liverpool 3½% (1960–70)
Birmingham 2½% (1966–71)

Essex County 3½% (1960–70)
Middlesex C.C. 4% Red. (1952–72)

Industrials

Barker (John) 4% Irred. Debs.
Dunlop Rubber 3½% 1st Debs.
English Electric 4% Red. Debs.

Lever Bros. 5% Cum. Pref.
Charrington 4% Cum. Pref.
B.A.T. 5% Cum. Pref.
Courtaulds 5% Cum. Pref.

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Public Boards

Met. Water Bd. 2¾% "F"
P.L.A. 3½% Reg. (1965–75)

Industrial Ordinary Share Index (*30*)

Distillers	Murex	Brit. Motor Corp.
Watney's Defd.	Pinchin Johnson	Hawker Siddeley
Associated Portland Cement	Spillers Ordinary	Leyland Motors
London Brick	Tate & Lyle	Rolls Royce
Harrods	Turner & Newall	Courtaulds
Woolworths	Wm. Cory	P. & O. Defd.
Electric & Musical Industries	Guest, Keen & Nettlefolds	J. & P. Coats
General Electric	Swan Hunter	Lancashire Cotton
Dunlop Rubber	Tube Investments	Patons & Baldwins
Imperial Chemical Industries	Vickers	Imperial Tobacco

Gold Mines (*30*)

Blyvooruitzicht	Robinson Deep	Grootvlei
City Deep	St. Helena	Modder. East
Cons. Main Reef	Simmer & Jack	New Kleinfontein
Crown	Venterspost	S. African Land
Durban Deep	West Rand Cons.	Sub. Nigel
East Rand Prop.	Western Reefs	Vogelstruisbult
Luipaards Vlei	Daggafontein	Free State Geduld
Western Holdings	East Daggafontein	Ashanti Goldfields
Randfontein Estates	East Geduld	Taquah & Abosso
Rand Leases	Government Areas	Lake View & Star

Government Securities Index (*11*)

Consolidated 2½%	National War 2½% (1954–56)	Funding Loan 4% (1960–90)
Consolidated 4% (1957 or after)	War Loan 3½% (1952 or after)	Funding Loan 3% 1959–69
Conversion Loan 3½% (1961 or after	Brit. Transport 3% (1978–88)	Savings 3% (1960–70)
Electric 3% (1968–73)		Savings 3% (1965–75)

TABLE 4

Comparison of Financial Times *Monthly Average Indices* 1953 *and* 1954

	Government Securities		*Fixed Interest*		*Industrial Ordinary*		*Gold Mines*	
	1953	*1954*	*1953*	*1954*	*1953*	*1954*	*1953*	*1954*
January . .	95	100	106	112	118	133	95	91
February . .	95	100	106	112	122	137	98	91
March . .	96	101	107	112	124	137	97	94
April . .	97	102	108	113	121	144	96	91
May . . .	98	103	108	115	116	149	89	87
June . . .	98	103	109	115	117	152	88	88
July . . .	97	105	109	116	120	159	88	87
August . .	98	106	109	117	123	166	88	96
September .	99	105	110	117	125	171	83	97
October . .	100	106	111	117	128	176	83	95
November .	101	106	112	118	130	179	82	94
December . .	100	104	112	117	129	180	85	95

1 (d). *The Actuaries' Investment Index*

(i) This index is compiled jointly by the Institute of Actuaries and the Faculty of Actuaries of Scotland. It is designed to provide an index of prices and average yields for high grade debentures, preference shares and ordinary shares of United Kingdom Companies—the class of securities which would be of primary interest to the Institutional investor.

As originally developed (with 31st December, 1938, base) the indices for various groups were the unweighted geometric means of the middle market prices on the last Tuesday in each month. Indices for aggregates were developed by combining on the same principle. The yield average for a group was the arithmetic average of the individual yields.

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In 1953 a completely new Index was started (with 29th December, 1950, base) but calculated back to 1946 in order to give an indication of the post-war long term trend. The new series incorporates a wider selection of ordinary shares and groups preference shares according to the nominal rate of dividend of each security; indices of debenture stocks and of gilt-edged securities are also included. To ensure that the Index is representative of current high-grade securities, an annual review is made of the component securities and there is also provision for the removal of a preference or ordinary share if its price falls below a fixed limit in relation to the Index of the group. These points must be borne in mind in interpretation.

One important change is that the major groupings of the ordinary shares are now more in line with useful broad economic concepts, being divided into "capital goods" securities and "consumption goods" securities. In calculating the equity index the geometric means of the group figures are now weighted, the weight assigned to each group is based on the market value of the securities at the new base date. The index is available by subscription, and is abstracted and quoted by *The Economist* and *The Financial Times*, etc. For a quick review and critique of the new index the reader is referred to *The Economist* (September 12th, 1953).

The overall trends shown in the old and new total indices are (fortuitously) similar, but naturally bigger differences are apparent when details are studied. In view of the major alteration in the list of constituent securities in the new index it cannot be linked in any way with the previous index.

The prices of fixed interest securities are adjusted to allow for accrued interest or dividends less tax; the equity yield index is based on the total dividend during the previous 12 months except in so far as the company report indicates other figures as more appropriate. The number of securities previously included (245) has been expanded to 323. The ordinary shares now total 243 (as against 138) and are grouped into "financial", "capital goods", "consumption goods" and "miscellaneous" sectors such as chemists, etc. Previously the groups were: production, distribution (mainly stores), miscellaneous (mainly breweries and distilleries).

TABLE 5

The Actuaries' Investment Index

	Price Indices (December 29th, 1950 = 100)		*Average Yields (Per cent.)*	
	December 30th, 1952	*December 29th, 1953*	*December 30th, 1952*	*December 29th, 1953*
2½% Consols	82·4	90·1	4·29	3·93
Debenture Stocks:				
Breweries and Miscellaneous	81·1	87·6	5·08	4·70
Investment trust	81·8	89·6	5·05	4·61
Preference stocks:				
Industrial	85·6	91·7	5·30	4·94
Investment trust	84·0	88·4	5·25	4·99
Ordinary stocks:				
Banks	81·2	99·3	4·98	4·23
Industrial insurance	97·8	114·4	5·80	5·04
Investment trust	110·5	135·0	5·69	5·24
Electrical engineering	93·7	102·9	5·91	5·78
Engineering	105·1	114·4	5·34	5·26
Motors and aircraft	105·1	118·1	6·36	6·11
Breweries	98·2	99·8	6·50	6·65
Chain stores	108·2	167·0	4·58	3·95
Cotton textiles	85·9	110·7	7·74	6·05
Household goods	90·3	112·0	6·62	4·98
Rayon	70·9	79·5	7·52	4·41
Tobacco	84·9	88·8	6·83	6·65
Wool textiles	79·4	102·6	6·48	5·64
Chemicals	114·0	128·9	5·51	4·96
Oil	104·7	125·5	7·14	6·42
Shipping	101·9	114·3	7·05	6·67
Total (capital goods)	102·9	112·5	5·87	5·83
Total (consumption goods)	91·7	110·8	6·48	5·70
Total industrial (all classes)	97·5	113·1	6·29	5·76

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1 (e). *Moodys Indices*

The following data are compiled regularly by Moodys Services Ltd. (4) and are available in detail to subscribers.

(i) *Equity share price index.*—Friday prices geometrically averaged, with a basis of 1947 average = 100, provide the weekly index figures. Up to January 1st, 1950, the index comprised 50 leading industrial equities. Thereafter 60 equities, selected to represent the whole industrial and commercial market, were substituted, forming a stratified sample as regards different sizes of market capitalizations and the various sections of the Stock Exchange Official List. Table 6 shows the

TABLE 6

Moodys Equity Share Price Index
1947 = 100

Year	*Highest (weekly)*	*Lowest (weekly)*	*Yearly Average of Weekly Figures*
1919	57·6	46·7	51·7
1920	61·4	37·6	48·8
1921	37·5	31·9	34·4
1922	44·3	33·9	40·2
1923	50·9	45·7	48·2
1924	55·3	47·5	50·8
1925	61·7	54·6	57·8
1926	61·8	59·8	60·3
1927	69·0	62·2	64·8
1928	76·3	70·6	73·9
1929	77·6	64·8	73·1
1930	65·1	53·0	59·6
1931	50·7	42·3	46·2
1932	51·7	39·3	46·2
1933	60·3	49·7	55·2
1934	65·0	61·7	63·4
1935	73·9	64·2	69·1
1936	84·7	75·8	79·2
1937	85·3	69·6	78·3
1938	69·6	60·9	64·0
1939	63·4	54·5	59·3
1940	59·6	43·5	52·2
1941	64·0	52·6	57·5
1942	73·4	60·7	65·5
1943	82·7	75·8	79·0
1944	91·0	81·4	85·8
1945	93·0	84·3	90·4
1946	105·5	90·0	97·3
1947	107·9	88·8	100·0
1948	102·5	88·0	92·9
1949	96·5	79·8	86·3
1950	91·4	81·0	85·5
1951	105·7	90·5	98·7
1952	92·2	75·6	81·7
1953	97·4	81·0	88·1

yearly average of the weekly (Friday) figures and the highest and lowest such figures recorded each year.

(ii) *Yearly index of earnings.*—The consolidated earnings available (expressed as percentages of the paid-up nominal equity capital) for the equity shares of the companies comprising the price index are averaged geometrically and an Index formed based on 1947 = 100. For the earlier years when consolidated earnings were not available, parent companies' earnings were written up in the proportion that 1946 consolidated earnings bore to parent companies' earnings of the same year. For 1951 and subsequent years the number of companies included has been increased to 150 and the arithmetic average of their earnings used. The companies included are stated to be broadly representative, as regards size and nature of activity, of those quoted in the "industrial" markets on the London Stock Exchange. (See Table 7).

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TABLE 7

Moodys Earnings' and Dividend Index

Year	*Earnings Index**	*Dividend Index†*
1926	59·3	33·7
1927	71·6	39·2
1928	69·0	40·9
1929	65·6	39·2
1930	55·4	33·4
1931	41·1	27·0
1932	36·3	24·0
1933	41·0	25·6
1934	48·9	31·2
1935	56·4	34·6
1936	65·7	39·9
1937	65·6	40·7
1938	58·5	37·9
1939	63·6	32·4
1940	55·8	31·6
1941	57·6	32·7
1942	58·4	33·0
1943	66·8	34·7
1944	66·2	35·4
1945	73·3	37·9
1946	88·5	44·3
1947	100·0	44·8
1948	120·9	45·8
1949	129·8	46·7
1950	159·3	53·7
1951	172·1	55·8
1952	145·2	56·1

* Average percentage on equity capital (1947 = 100)

† Average percentage on equity (nominal paid-up) capital as percentage of 1947 earnings index.

(iii) *Yearly index of dividends.*—Averages of the percentages paid as yearly dividends on the equity shares of the companies included in the Yearly Earnings Index. Thus the yearly indices of earnings and dividends show the percentages earned and declared on their corresponding equity capital in each calendar year by representative industrial companies. These indices are kept up-to-date monthly by two further series ((iv) and (v)) which show the effect of current declarations of earnings and dividends monthly, including any "interim" payments.

(iv) *Monthly earnings ratio.*—A further 150 industrial companies are also stratified according to the spread of financial year-ends, throughout the calendar year, and speed of publication of accounts. The latest percentage figure of earnings available for the equity shares of each company is entered under the month in which it is published and repeated for the following 11 months. The geometric average of each month's figures represents therefore the latest known earnings of the 150 companies. The monthly average alters each month to the extent of changes in individual companies' earnings published during that month; changes in equality capital base are, of course, taken into account.

(v) *Monthly dividend ratio.*—Geometric averages of the percentages currently declared as dividends (on the corresponding equity share capital base) in the same 150 companies as are included in the Monthly Earnings Ratio.

(vi) "*Confidence*" *index.*—The Weekly Equity Share Price Index, together with a Dividend Index on the same 60 companies and a Consols Price Index* are used, by means of the formula:

$$\frac{\text{Equity Index} \times 100 \times 100}{\text{Consol Index} \times \text{Dividend Index}}$$

* See Table 8.

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TABLE 8

Consol Price Index

Yearly Averages 1925–53; (1947 *average* = 100)

1925	62·3	1939	74·0
1926	60·7	1940	80·9
1927	60·5	1941	88·1
1928	61·8	1942	91·0
1929	59·9	1943	88·8
1930	61·6	1944	87·7
1931	62·7	1945	94·3
1932	73·5	1946	106·3
1933	81·4	1947	100·0
1934	89·3	1948	86·0
1935	95·2	1949	83·5
1936	93·6	1950	77·7
1937	84·1	1951	72·7
1938	81·7	1952	64·7
		1953	67·4

TABLE 9

Moodys Confidence Index

Yearly Averages 1925–53; (1947 = 100)

1925	105·7	1940	81·6
1926	108·4	1941	83·7
1927	122·9	1942	94·1
1928	131·5	1943	111·7
1929	124·1	1944	119·0
1930	101·8	1945	115·3
1931	90·4	1946	106·5
1932	90·5	1947	100·0
1933	106·7	1948	102·7
1934	110·2	1949	97·2
1935	102·9	—	—
1936	108·0	1950	102·3
1937	106·4	1951	116·8
1938	90·0	1952	102·0
1939	94·6	1953	102·3

to provide what is termed a "Confidence" Index. (See Table 10). The value of this index depends on the underlying argument that three major factors influence the price movements of equities: namely, money rates, dividends and the market's general "confidence" in the future. The formula eliminates the effect of the first two influences on share prices, and brings out that due to changes in expectations.

(vii) *Trends in the indices.*—Yearly averages derived from the foregoing indices are recorded above. These, it is hoped, provide a handy reference to, and useful indication of, the general movement such indices have reflected over the last 25–30 years, but detailed study of the original data is essential.

1 (f). Investors' Chronicle *Indices*

Each month the *Investors' Chronicle* publishes security indices based on the middle closing prices on the last Friday in the month. The data are thus at variable 4–5-weekly intervals. The indices cover six broad groups subdivided into 33 "markets". The price changes are based on records for some 200 major securities. (These indices provide a continuous record of price changes on the London Stock Exchange since 1924.)

In the course of time it has been found useful to make new divisions of the markets which have led to the introduction of new indices for specialized groups. These indices have been taken in either at the level of indices they have replaced or at the equivalent of the General Industrial Index. For these the base is not the original base of December 31st, 1923; of course, the relative change is all that matters for current work and their introduction is not thought to have had any appreciable effect on the general long term trends.

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The *Investors' Chronicle* has published an "Industrial" Dividend Index for some years and recently introduced a "Confidence" Index (details are to be found in the issues of January 29th, 1944, and November 15th, 1952, respectively). These are based on the material provided by the Actuaries' Investment Index. The Confidence Index is merely:

$$\frac{100{,}000}{\text{Actuaries' } 2\tfrac{1}{2}\% \text{ Consols Index} \times \text{average yield on shares in Actuaries' "Industrial Ordinary" index}}$$

on analogous lines to that developed by Moodys Investors Services Ltd. (See 1 (d), iv.)

A weekly summary is also provided of data from *The Financial Times* daily indices, including *The Financial Times* index of Industrial Activity (this "activity" it should be noted, refers to the *volume of trading* which has taken place in the buying and selling of Industrial shares *so far as* they are reflected in Stock Exchange "*markings*"). Naturally this and other specialist newspapers and periodicals such as *The Stock Exchange Gazette* and *The Statist* also provide articles concerning groups of companies, etc., containing a good deal of what relevant statistical information is quickly securable.

1 (g). The Bankers' Magazine *Securities Values Index*

The Bankers' Magazine(5) has compiled, since 1921, indices of the market values of 87 fixed interest stocks and 278 variable dividend securities at closing prices on the 14th, 15th or 16th of each month. The par value is also recorded. Securities "nationalized" in recent years have been retained at vesting prices "to maintain comparability". The valuation now covers some £6,683m. nominal security value, with a market valuation at December 15th, 1954, of £6,974m. The calculation reflects the current discounts on fixed interest stocks (nominal value then £5,048m.; market value £4,428m.) and the difference between original nominal amounts and the current appraisal in variable dividend securities (nominal value £1,635m.; market value £2,546m.). The bringing of nominal capital more into line with current shareholders' monetary equity after years of inflation, when capital structure adjustments have been subject to controls, is, of course, a necessary, but necessarily slow, process. The data are also plotted in the form of indices on December 15th, 1921, as base, which are charted by arrangement by the Exchange Telegraph Co., Ltd., in card form, for subscribers to their services.

1 (h). *A Note on Security Indices Generally*

Shares, no matter how representatively selected initially, change their nominal paid-up capital base in the normal process of capital growth or decline, amalgamations, etc. Bonus issues may sometimes unduly affect the market value temporarily. In the long run, any relatively small set of shares tends to lose representativeness owing to shifts in economic importance or indeed shifts in the nature of trade within and between industries. If a new share is created with preferential rights over existing ones it will naturally have an effect on the market values of the latter. Even in the short run, the presence of special technical factors may sometimes prevent an index adequately reflecting the net effect of movements within the various markets.

A nominal capital of £10,000 created in 1900 may well be equivalent in real terms to a new issue of £100,000 in 1950. To some extent prices and "share-splits" will automatically allow for this, but on any one day chosen as base date for an index it is most unlikely that all shares will be correctly aligned for weighting purposes. For short term purposes, however, such indices are found to reflect significant movements in a most serviceable way. Long term indices are much more difficult to interpret, especially as the rates of expansion of capital base may prove highly variable as between constituent groups. Fortunately, however, such "details" do not usually alter the general shape of the trend, which in long term measurement is often all that is required, the exact magnitudes involved being of secondary importance.

The majority of indices, dealing with wide ranges of prices, are based on the geometric means of current prices as a percentage of the corresponding figures at a base date. The latter are "suitably adjusted"* when bonus or other issues affect the nominal value involved. In practice, of course,

* Precise information as to the nature of such corrections does not appear generally to be published, but it is assumed that the most "practical" way will be adopted, viz. to adjust the (logarithmic) base proportionately to the change in nominal capital or market value involved.

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arithmetic means of the logarithms are taken, while weights are selected, in whatever way seems most suitable for the special purpose, from whatever data are constantly and uniformly available. Many indices, however, are simply unweighted.

The selection of prices to be used is also somewhat arbitrary or indefinite ("middle closing", "on last Tuesday in month", etc.). For a further discussion see Kendall(6).

Since dividends and other monetary items on which indices are formed must still (since "no par value" shares are not common) be associated with a nominal capital base, many indices which are at present unweighted should more strictly be weighted according to the nominal capital they represent or reflect.

The Bankers' Magazine Securities Values Index(7), which is based on the addition of market values, is one of the few partially taking this step specifically, though naturally the stratification present in many samples partially allows for this factor implicitly. For many purposes it would be valuable to relate such items to figures more directly associable with actual or real capital employed, including, of course, loans and overdrafts. The weights necessary in such cases could diverge considerably from those required for use on nominal capital bases. At present only a subjective assessment of the possible effect on the trends of indices can be made. It must, however, be admitted that these types of refinement, in the absence of a chartable framework and for other technical reasons due to the constant changes, might be offset by even greater difficulties of interpretation. The existing data, although imperfect, do convey a story succinctly and, because of the presence of linkages within the price structures of the markets, reflect closely the situation experienced subjectively by the trained investment observer, and appear to have stood up to the practical test of time.

1 (i). *The Annual Stock Exchange Valuation of Securities*

(i) The Records Office of the London Stock Exchange calculate yearly the apparent current market valuation, the nominal amount in issue, and the number of shares and securities quoted in the Official Lists at a date towards the end of March (now March 31st). Sub-totals are published (2) for 39 broad groups corresponding in general to the sections of the *Daily Official List* and *Stock Exchange Official Year-Book*. Not all the securities covered are, of course, British owned or created. In many groups such as "commercial", "Railways" or "foreign stocks" will be found a few securities in which the nominal capital is stated in foreign currency. These are converted at suitable official sterling rates. The difficulty remains regarding the bulking together of nominal capitals at different dates as a real economic concept.

A number of foreign companies have shares with no par value. The market valuation of these units is included in the totals; but no group data were published before 1954 to enable these totals to be deducted if a direct comparison between the recordable nominal value and the corresponding market value for the remaining securities is wanted for earlier years.

The majority of the securities in the "private" sector are connected with public limited liability companies, and chartered or statutory companies; it is possible, however, for a private company to have publicly subscribed and quoted debentures and there are a few at present outstanding. The transfer of ownership of iron and steel shares and debentures to the Iron and Steel Corporation and back again complicates the tables. Many companies in this group became in effect investment trusts on receipt of the proceeds of the sale to the public corporation; so, too gas, electricity and transport groups have been affected in recent years.

Transfers from one section to another may occur from time to time, e.g. the figures for "Telephones and Telegraphs" were considerably modified when Cable and Wireless Limited was taken over by the government and the holding company was regarded as more appositely classifiable as an "investment trust".

A number of companies are subsidiaries of other public companies though not "wholly owned". A number of "wholly owned" companies are listed in *The Stock Exchange Official Year Book* for convenience of record but such shares are not included in the valuation. A small amount of duplication, which will vary in strength between industrial groups, may arise in consequence.

Such data may thus not be safely extendable or interpretable over long periods of time, but figures are usually given for a moving period of 3 years, in which relevant factors can be allowed for by investment experts.

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Market valuations so assessed could, of course, never be realized in a sustained heavy sale of *all* securities.

The data originated in the Reports of the Committee for General Purposes(2) and go back, in various forms, as indicated by the table, to 1931. The valuation is at the lower quoted price in the Official Lists on the date specified. Table 10 summarizes the total estimated nominal amount and the corresponding market valuations (including no par value shares, and those in foreign currency denominations) at roughly yearly intervals over the period.

An analysis is also made at the same time of quotations granted by the Stock Exchange Council during the year. This provides certain figures regarding nominal amounts, cash subscribed, other "consideration", commission and underwriting costs. "New Capital Issues" which have secured a quotation will form a part of this total.

The details can also be grouped to enable broad comparisons to be made to show trends in the various types of capital involved. Table 11 (p. 80) indicates the percentage of total nominal amount and of market valuations enjoyed by various groups in selected pre- and post-war years.

(ii) The following table summarizes material available annually since 1931 concerning total nominal amount and market valuations at specified dates.

TABLE 10

Nominal Amount and Market Valuation of Quoted Securities (London Stock Exchange)

	Number of Quoted Securities		*Nominal Amount*		*Market Valuation*	
	D.L. No.	*S.L.* No.	*D.L.* £m.	*S.L.* £m.	*D.L.* £m.	*S.L.* £m.
December 31st, 1931	5,927*		18,458*			
December 31st, 1932	5,959*		18,371*			
December 31st, 1933	5,863*		18,476*			
March 24th, 1934	5,344		17,584			
March 24th, 1935	5,351		17,454			
March 24th, 1936	5,443		17,375			
March 24th, 1937	5,522		17,698*		19,475	
March 24th, 1938	5,629		17,930		17,347	
March 24th, 1939	5,693	4,604	17,976	1,812	16,824	1,683
March 24th, 1940	5,681	4,333	18,209	1,261	17,624	1,599
April 7th, 1941	5,551	4,270	16,983	1,166	15,224	1,250
April 7th, 1942	5,501	4,326	18,421	1,157	17,457	1,237
April 5th, 1943	5,465	4,420	19,557	1,174	19,801	1,527
April 3rd 1944	5,422	4,426	20,496	1,168	21,039	1,677
April 3rd 1945	5,313	4,302	21,039	1,120	22,553	1,822
April 1st 1946	5,236	4,379	21,836	1,184	23,812	2,329
April 8th, 1947	5,184	4,757	22,066	1,327	25,206	2,872
April 5th, 1948	9,821		22,973		26,573	
April 4th, 1949	10,053		22,904		26,163	
April 3rd, 1950	9,711		22,949		25,067	
April 2nd, 1951	9,706		23,623		26,991	
March 31st, 1952	9,708		24,894		25,443	
March 31st, 1953	9,752		25,624		27,130	
March 31st, 1954	9,861		25,653		30,503	

D.L. = Daily List. S.L. = Supplementary List.

* Including securities removed from the Daily List owing to absence of recorded "bargains".

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TABLE 11

Market Valuation Compared with Nominal Amount in Selected Years
Distribution by Broad Groups of Quoted Securities

	March 24th, 1939.			*April 4th, 1949.*			*March 31st, 1953.*		
Group	*M.V. as % of N.A.*	*M.V. as % of Total*	*N.A. as % of Total*	*M.V. as % of N.A.*	*M.V. as % of Total*	*N.A. as % of Total*	*M.V. as % of N.A.*	*M.V. as % of Total*	*N.A. as % of Total*
1	77	56	68	93	64	79	82	62	80
(of which a)	(95	44	43)	(102	60	68)	(88	58	70)
2	169	25	14	221	25	13	186	26	14
3	98	19	18	157	11	8	214	12	6

	March 24th, 1939.		*March 31st, 1953.*	
	Market Valuation £m.	*Nominal Amount £m.*	*Market Valuation £m.*	*Nominal Amount £m.*
(a)	8,140	8,539	15,872	18,012
(b)	1,677	2,073	625	470
(c)	510	2,789	230	1,890
(d)	1,328	858	1,791	922
(e)	3,276	1,873	5,370	2,816
(f)	2,193	2,012	911	712
(g)	1,384	744	2,333	803
Total £m.	18,507	19,787	27,130	25,623

(a) British Funds and Guaranteed Stocks, Trade Facilities Act Securities. Corporation stocks—Great Britain and N. Ireland. Corporation stocks—Dominion and Colonial. Dominion, Provincial and Colonial Government securities; Indian Raj Loans.
(b) Public boards; gas; iron, coal and steel; waterworks; railways (Great Britain and N. Ireland), canals and docks.
(c) Corporation stocks—foreign; foreign stocks, bonds, etc.
(d) Banks and discount houses; insurance; financial trusts, land and property; investment trusts.
(e) Breweries and distilleries; commercial and industrial, etc.
(f) Railways, overseas; electric light and power; shipping; telegraph and telephones; tramways and omnibus.
(g) Mines; nitrate and oil; rubber, tea and coffee.

Group 1 = (a) + (b) + (c)
Group 2 = (d) + (e)
Group 3 = (f) + (g)

The amounts attributed to shares of "no par value" in market valuations in recent years have been as follows:

	Market Value	*No. of Shares*
At April 2nd, 1951	£810m.	122m.
March 31st, 1952 . . .	£829m.	141m.
March 31st, 1953 . . .	£796m.	139m.

Further details are available from the Annual Valuation Statistics for all companies, by sections, as at March 31st, 1954, dividing the securities into Loan Capital; Preference and Preference Share Capital; Ordinary and Deferred Capital; shares of no par value are shown separately by sections for the first time.

At 31st March, 1954	*Nominal Amount £m.*	*Market Valuation £m.*	*M.V. as % of N.A.*	*N.A. as % of Total N.A.*
Loan Capital . . .	992	850	86%	17%
Preference and Preferred	1,485	1,495	101%	25%
Ordinary and Deferred .	3,475	9,643	278%	58%
Total with Nom. Value .	5,952	11,988	200%	100%
No par value shares .	..	900	..	

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In a recent article contributed to *The Banker* (Oct., 1954) Miss M. S. Rix has analysed the market valuations of large companies and related to the total, as follows:—

TABLE 12

Large Companies, Worth £10 *Million Upwards*

Market Valuation at March 31st, 1954, *and as* % (*italic figures*) *of Corresponding Group Totals*

	Large Companies (including no par value shares)					*All Quoted Companies*	
		Valuation in £m.					
	No.	*Loan*	*Pref.*	*Ord.*	*Total*	*No.*	*Total Valuation in £m*
Financial, etc.:							
Banks and Discount Cos.	20 *32*	32·4 *100*	— —	516·8 *80*	549·2 *80*	63	686·6
Insurance	16 *35*	0·4 *48½*	6·3 *71½*	388·7 *80½*	395·4 *80*	46	494·3
Investment trusts	6 *2½*	21·9 *16*	6·9 *6*	52·2 *15½*	81·0 *13½*	258	590·4
Financial land, etc.	7 *2½*	4·8 *8*	4·0 *8½*	107·5 *41½*	116·3 *32*	288	365·0
Industrials:							
Commercial, industrial	95 *3½*	120·7 *50*	426·0 *45½*	2,700·5 *56½*	3,247·2 *54½*	2,592	5,955·5
Breweries, etc.	11 *5*	33·7 *35*	23·8 *25*	234·4 *60*	291·9 *50*	222	581·0
Iron, coal and steel	10 *7*	20·1 *69*	18·3 *41½*	168·8 *50*	207·2 *50½*	140	409·6
Shipping	6 *11*	4·8 *99*	10·2 *40*	85·1 *56*	100·1 *55*	55	181·7
Commodities:							
Oil	8 *23½*	24·3 *78·*	45·2 *86*	1,043·1 *95*	1,112·6 *94*	34	1,180·3
S.A. mines (excluding diamond)	26 *19½*	18·8 *65½*	5·5 *50½*	522·4 *70*	546·7 *69½*	134	787·2
All other mines	18 *7*	1·5 *19½*	30·0 *93*	443·8 *74½*	475·3 *75*	263	635·4
Rubber and tea	—	—	—	—	—	606	93·7
Others:							
Railways	5 *6½*	81·5 *64*	18·4 *29*	184·2 *89*	284·1 *71*	76	399·2
Utilities	8 *4½*	13·4 *25½*	8·5 *15*	226·1 *59½*	248·0 *51*	182	487·7
Total	236 *5*	378·3 *44½*	603·1 *40*	6,673·6 *63½*	7,655·0 *59½*	4,959	12,847·6

(The above table is taken from Miss Rix's article, "How Important are Large Companies". *The Banker*, 103, No. 345 (October, 1954).)

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TABLE 13

(£ *millions*)

A. Income Data	*1946*	*1948*	*1949*	*1950*	*1951*	*1952*	*1953*
1. (i) Gross trading profits of companies (a, b, c, d)	1,480	1,795	1,861	2,144	2,502	2,269	2,463
(ii) Gross trading surpluses of public corporations (a, b, e)	17	115	154	194	255	273	302
(iii) Gross profits of central and local government trading bodies (b, f)	91	113	112	147	124	49	66
2. (i) Trading profits of British companies operating abroad (g)	138	219	192	309	313	202	218
(ii) Income earned abroad by public corporations	—	—	(−1)	1	—	1	2
3. Non-trading income (h):							
(i) companies	260	306	304	320	344	383	412
(ii) public corporations	8	24	24	25	26	29	31
Total (exc. Item 3): corporate income	1,903	2,459	2,534	3,043	3,470	3,187	3,488

(a) Operating in the United Kingdom.
(b) Including depreciation and stock appreciation.
(c) Including co-operatives, building societies, etc.
(d) Imputed income from business premises owned by the occupier is included.
(e) Nationalized industries.
(f) Treatment of losses varying according to trading policy (see page 85 of the "1946–52" Blue Book; a list of these bodies is also provided there).
(g) *Excluding* depreciation, but including stock appreciation.
(h) Mainly rent and interest on public debt securities held.

(£ *millions*)

B. Allocation of Corporate Income in "A" above	*1946*	*1948*	*1949*	*1950*	*1951*	*1952*	*1953*
1. (*a*) Debenture interest paid by companies	48	35	28	31	36	41	46
(*b*) Preference interest paid by companies	128	117	103	104	104	102	100
(*c*) Ordinary dividends paid by companies	356	395	391	403	459	445	513
(*d*) Other payments by companies (x)	84	81	87	91	97	133	148
Companies' total distributions	616	628	609	629	696	721	807
(*e*) Public corporations' interest payments	11	58	86	91	106	118	131
2 Additions to interest and dividend reserves	31	(−1)	4	50	9	50	55
3. Remittances and taxes paid abroad	83	87	91	104	144	169	151
4. U.K. taxation payments.							
(*a*) Companies	649	564	743	761	710	931	926
(*b*) Public corporations	2	3	2	3	4	3	24
5. U.K. additions to tax reserves—							
(*a*) Companies	(−100)	182	(−23)	66	427	7	12
(*b*) Public corporations	—	(−1)	3	2	23	33	12
6. (*a*) Undistributed income of British companies after taxation (y, z)	600	880	935	1,169	1,179	981	1,147
(*b*) Undistributed income of public corporations after taxation (y, z)	11	59	84	118	142	144	163
Undistributed income before tax—							
Companies (y)	1,149	1,626	1,655	2,046	2,346	1,949	2,145
Public corporations (y)	13	61	89	123	169	180	199

(x) Co-operative share deposit interest and "divi", building societies, bank deposit interest, etc.
(y) Including depreciation and stock appreciation provisions.
(z) i.e. after deduction of tax payments and additions to tax reserves.

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TABLE 13—*cont.*

C. Total Investment at Home and Overseas	*1946*	*1948*	*1949*	*1950*	*1951*	*1952*	*1953*
				(£ *millions*)			
1. Gross fixed capital formation	900	1,396	1,544	1,682	1,866	2,066	2,333
2. Value of physical increase in stocks and work-in-progress	(−107)	153	35	(−216)	600	50	201
3. Net investment abroad	(−298)	139	185	440	(−342)	255	225
Total investment	495	1,688	1,764	1,906	2,124	2,371	2,759

D. Miscellaneous	*1946*	*1948*	*1949*	*1950*	*1951*	*1952*	*1953*
				(£ *millions*)			
1. Stock appreciation	125	325	200	650	750	(−50)	(−75)
2. Rents, dividends and interest received by persons (a)	1,151	1,184	1,225	1,267	1,293	1,395	1,491
3. Personal savings and provision for depreciation and stock appreciation (b)	245	59	95	102	237	706(d)	870
4. National Saving (c)	456	1,770	1,800	2,364	2,770	2,297	2,579

(a) The separation of "rents received" from this figure is of considerable investment interest. The 1954 Blue Book now provides global figures, for 1953, of rent received by persons (£268 m.) and broad economic groups. Dividends and interest accruing to private individuals from sources at home and/or abroad, for 1953, is thus put at £1,223 m.

(b) "Persons" including partnerships, farmers, the few agricultural companies, and sole traders, etc., so that a considerable amount of stock appreciation and depreciation is involved with wider margins of error even than that normally associated with the "savings" figures, which is mainly of a "residual" nature.

(c) Including provisions for depreciation and stock appreciation. The Blue Book main tables no longer attempt to separate "depreciation" from "saving". The total figure for "national saving" now balances with figures for gross fixed capital formation, stock appreciation, the value of the physical increase in stock and work-in-progress, net investment abroad, and capital transfers abroad. No distinction can at present be made, in the figure for fixed capital formation, between the replacement of existing assets and additions to the stock of such items.

(d) The 1953 Blue Book (10) gave £502 m.

E. Depreciation

Figures for certain components of depreciation are given in appendices to the Blue Books, but severe technical restrictions on their use are stressed. The sub-total analysed rises steadily between 1946 and 1953:

Depreciation (mainly statutory allowances)—	*1948*	*1952*	*1953*
			(£ *millions*)
Central Government trading	28	36	37
Public corporations	71	143	156
Companies (a)	302	402	486
"Persons" (b)	77	100	109
Total	478	681	788

(a) Excluding companies operating overseas; initial and annual allowances only.
(b) As in note (b) above.

1 (j). *Government Published Data on Trading Profits and Dividends*

(i) The series of National Income and Expenditure white papers and blue books(9) provide certain estimates of overall trading profits and receipts of individuals from investment. These are essentially Inland Revenue figures. The nature of these figures is highly complex and cannot be associated specifically with the trends for joint stock companies quoted on the Stock Exchange.

Each year the series are revised in the light of further information received, so that it is difficult to obtain an accurate series over a longish period of time. The year-to-year data are affected to some extent by special circumstances; also, with the absorption of many companies into nationalized

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or public corporations, increases shown in the operating profits of public enterprises may merely reflect a change in the industrial base, and conversely; the figures for trading profits relate to all limited liability companies, private or public, as well as unlimited companies and other corporate bodies.

Duplication of dividends between companies is, however, avoided through the ability to separate "franked"* income from global taxation data. The technical treatment of the various figures for trading companies and public corporations is fully annotated in the white papers themselves, so that here we would merely note that depreciation may either be included or excluded from the definitions; that preliminary stock appreciation figures are often subject to considerable later adjustment; and that dividend figures include the "divi" of co-operative societies.

(ii) An extract of the main relevant tables in the Blue Books (10) (Table 13) may perhaps be handy for quick reference, but appraisal or interpretation still rests on a close study of all definitions in the original document.

1 (k). *National Debt and Related Data*

(i) A Government White Paper issued each year(11) indicates changes in the composition of the national debt during the fiscal year and the year-end position; gives a handy summary of debt created and redeemed in the year; and interest data on Treasury Bills, Saving Certificates, and Government securities in general: series from 1938 onwards are provided for many items.

(ii) The Annual Return of the Bank of England(12) shows its position at the end of February, and provides a quick summary of historic data (periodic) series on such things as note issue, circulation, short term money rates and the floating debt. It gives a statement of the Balance Sheets of the London Clearing Banks at the same date, and comparisons over a number of years, while their total holdings of investments are also recorded.

Details of public and Government debt managed by the Bank are given, together with a résumé of the operations regarding new issues, conversions and repayments of gilt-edged securities and Treasury Bills which have taken place in the twelve months.

2. FINANCIAL ANALYSES OF AN INDUSTRIAL CHARACTER

2 (a). The Financial Times *Trend of Industrial Profits Analyses*

(i) *The Financial Times* provides, monthly, a cumulative total from the beginning of the calendar year, of company profits and other consolidated balance sheet details which have been published and been made available to them during the period. The figures by the end of each year cover the great majority of accounts in those public companies connected with industry and commerce, or with British trading overseas, which are quoted on the Stock Exchanges. Comparison is made with the corresponding figures for the same companies' previous year's trading, but it should be borne in mind that the date of issue of company reports from one year to the next is to some extent variable (thus figures given for the position at the end of May, say, in 1952, derived from the corresponding 1953 analyses, do not necessarily cover the same number of companies, nor indeed, quite the same companies as those to be found in the analysis published at the end of May, 1952).

It is thus not strictly legitimate to collate such analyses into a 12-month moving total. The trading period to which company balance sheets relate are always some months behind the date when they are included in the analysis, and they will differ in time lag substantially between groups and according to the nature and size of the company. Thus, for example, big stores and variety chains may produce figures for the previous calendar year by March or April, whereas the results for many other companies in the drapery and store group, with possibly quite different profit records, may not appear until much later. Companies trading overseas also have a longer time lag while material is being received from abroad.

Thus the figures during the early parts of the year may not always be indicative of changes in conditions of trading for the *group as a whole* during the (suitably time lagged) previous trading year. For investment specialists, however, who know which companies' balance sheets have been published

* Dividends received out of income that is liable to Profits Tax. For a critique, dealing with certain aspects of the official figures for savings by companies and by persons, the reader is referred to T.K. Gribbin's article(48).

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TABLE 14

The Financial Times *"Trend of Industrial Profits" Analyses*

		Cumulative (£ *millions.*)						
Total Industrials (a)	*No. of Cos.*	*"Profits"* (b)	*"Deprec."* (c)	*"Tax"*	*"Ord. Divs."* (d)	*Issued Ord.*	*Cap. and Rev. Res. Totals* (e)	*Net Working Capital* (f)
Mar., 1950 (g)	583	206·1	23·7	84·7	26·5	257·6	346	458
		(195·6)	(20·0)	(84·2)	(26·1)	(237·2)	(314)	(429)
June, 1950	1,518	664·0	96·7	265·5	71·7	816·1	1,324	1,469
		(629·9)	(79·1)	(265·2)	(70·3)	(757·5)	(1,198)	(1,360)
Sept., 1950	2,093	902	129·1	365	94·9	1,116	1,838	2,020
		(840)	(106·6)	(354)	(92·3)	(1,036)	(1,653)	(1,850)
Dec., 1950	2,757	1,146	164	464	117	1,368	2,342	2,467
		(1,051)	(138)	(440)	(113)	(1,282)	(2,094)	(2,252)
Mar., 1951	664	251·6	26·1	109·7	32·9	275·8	458	569
		(222·5)	(23·5)	(96·3)	(29·6)	(267·9)	(403)	(509)
June, 1951	1,703	902	118	384	87·1	901·3	1,815	1,896
		(743)	(101)	(306)	(78·8)	(861·2)	(1,482)	(1,684)
Sept., 1951	2,322	1,160	148	498	111	1,196	2,308	2,434
		(943)	(130)	(391)	(101)	(1,144)	(1,920)	(2,158)
Dec., 1951	2,970	1,436	181	627	132	1,458	2,785	2,929
		1,154)	(160)	(481)	(121)	(1,381)	(2,337)	(2,577)
Mar., 1952	612	322·4	32·6	146·5	31·3	298·6	534	650
		(271·3)	(29·9)	(115·6)	(31·5)	(282·7)	(474)	(575)
June, 1952	1,637	1,048	137·7	475·6	85·8	967·5	2,189	2,213
		(898)	(122·7)	(380·3)	(84·1)	(893·5)	(1,814)	(1,909)
Sept., 1952	2,265	1,355	173	622	113	1,302	2,766	2,854
		(1,177)	(153)	(506)	(110)	(1,205)	(2 323)	(2,490)
Dec., 1952	2,924	1,613	211	741	136	1,581	3,282	3,394
		(1,448)	(186)	(633)	(131)	1,455)	(2,821)	(2,976)
Mar., 1953	571	258·4	30·2	122·7	67·0	313·0	467·3	660
		(292·2)	(28·1)	(134·0)	(82·4)	(275·2)	(450·8)	(612)
June, 1953	1,693	917·8	140·0	412	91·2	1,048	2,107	2,277
		(1,003·5)	(127·6)	(544)	(83·9)	(944)	(1,964)	(2,129)
Sept., 1953	2,275	1,173	176	525	119	1,373	2,710	2,936
		(1,292)	(161)	(591)	(109)	(1,246)	(2,520)	(2,738)
Dec., 1953	2,911	1,397	209	627	143	1,656	3,196	3,427
		(1,529)	(193)	(708)	(130)	(1,504)	(2,964)	(3,205)
Mar., 1954	569	332	45·4	160	43·5	408	598	745
		(305)	(39·6)	(152)	(34·4)	(379)	(546)	(694)
June, 1954	1,599	1,065	161	467	116	1,226	2,289	2,456
		(963)	(151)	(442)	(94)	(1,109)	(2,136)	(2,318)
Sept., 1954	2,195	1,349	203	598	147	1,595	2,913	3,124
		(1,216)	(193)	(555)	(121)	(1,429)	(2,709)	(2,940)
Dec., 1954	2,825	1,670	250	736	180	1,978	3,543	3,787
		(1,500)	(236)	(686)	(148)	(1,756)	(3,306)	(3,566)

Notes.—(Corresponding figures for previous years are shown in brackets).

(a) In addition, *The Financial Times* records data for certain groups trading overseas such as Mines, Plantations, Oils, etc. During 1950 there were 804 companies so analysed; during 1951, 817; during 1952, 808; in 1953, 771. Space precludes listing here of corresponding data by specific market group.

(b) Profits include normal investment income, but exclude exceptional capital windfalls.

(c) Usually the standard depreciation allowance for income tax, but accountancy treatment of initial allowances on new plant and replacement costs makes the figures somewhat unprecise.

(d) The *net* cost of dividends on equity capital. The total earned for ordinary dividends, i.e. the net profit accruing to equity shareholders after meeting fixed charges and pension funds is also given in the tables, but omitted here. The definition of equity is somewhat loose since many preference shares have an equity element, while many ordinary shares themselves have some preferential element, while "equity" legally covers both types of share capital.

(e) The allocations to these reserves made during the year are also shown in the tables, but omitted here.

(f) Current assets, less current liabilities and provisions.

(g) The series was first published on March 4th, 1950, to cover reports received in the two months Jan. and Feb., 1950, with corresponding data for the same companies in 1949.

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in each group, the analysis provides a most convenient summary, which is of considerable use. Its publication has unfortunately led to political misquotation, which is to be deplored; such financial statistics are of an extremely complicated character fitted to an extremely complex business community. The "ordinary dividends" total, given for instance, represents the *net* cost to the companies, i.e. after deducting income tax payable to the Inland Revenue on shareholders' behalf; it is quite possible for an increase in ordinary dividends to occur from one year to the next, if the standard rate of income tax is lowered, without any increase—and indeed sometimes a decline—in the gross amount paid out by the company to its shareholders.

There is a certain element of duplication in such dividend figures, arising from the fact that dividends paid out from one company may be included in the "franked" income of another company holding such securities; for example, in the oil market group, where substantial interlocking of company holdings occur. The change from month to month, however, in the cumulative figures for ordinary dividends declared will reflect fairly closely the rate at which such monies are being distributed into the economy from public companies. The main data for 1950–1954 are recorded in Table 14. The index is divided in a reasonably practical way, if inevitably such divisions must remain subjective, into some 28 groups, whose titles broadly reflect the main interests of the companies included and the Stock Exchange "markets" in which they are dealt in. Data for the exceptionally diverse Unilever group have to be placed in the miscellaneous industrials total; care is taken to see that the data here relate only to the United Kingdom company. On the other hand, a number of companies are not registered in the United Kingdom, as in the South African gold mine group. A considerable amount of the dividends may not accrue to investors in this country, although they may well be paid to the London branches of foreign banks, etc.

It must be borne in mind always, in dealing with all figures for "ordinary" shares, that some preference shares have an element of ordinary equity in them, while some shares treated as "ordinary" may themselves have a preferential element.

Changes may also occur between the two years in the nature or nominal amount of issued "ordinary" capital on which the dividends are paid.

2 (b). The Economist *Quarterly Profit Analyses*

The Economist newspaper also analyses the reports of public companies which it receives, on a quarterly basis in a somewhat different form. Direct comparisons are again made of the aggregates, in trading accounts, between the latest year's figures and those recorded for the previous year. The companies included in any one quarter's statement may thus differ slightly from those included in the corresponding analysis made a year before. Time-lags between trading year covered and date of publication of corresponding accounts, must be allowed for subjectively.

With the exception of rubber and tea companies, the modal time-lag appears extremely constant at roughly 4 months. Thus, as with the Moodys indices previously referred to, the published figures will normally reflect the situation averaging about the middle of the financial year and so be approximately 10 months in arrear. On occasions an exceptional delay has occurred in the publishing of accounts for one or two companies predominating in one of the groups, such as "Oil." This may disturb comparisons for a temporary period, but the reason will be self-explanatory to the specialists studying the group data.

Comparisons between one quarter and that directly preceding it would, of course, be between distinct sets of companies, with different trading years and with possibly different weightings between industries or size groups. Comparisons over periods of time serving to point out trends are thus made by considering the variation in the percentage changes derived from the quarterly series of direct comparisons.

The relative changes recorded in this way are felt to be very reliable. It should, of course, be borne in mind that the percentages given relate not to a quarter's trading but to the whole year's trading for the accounts published in each quarter. Accounts of subsidiary companies are not duplicated, since only consolidated balance-sheet data are tabulated.

The data cover some 31 economic groups, including the majority of British industrial and commercial activities. British-owned investment trusts, overseas utilities and plantations are included, but mines, banking and insurance are omitted. The material is usually presented under 23 groups (including a "miscellaneous" entry). Details were formerly recorded in the *Record and Statistics*

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Supplement, but are now given in the statistical section of *The Economist* early in the succeeding quarter, at the same time as the summary article reporting the general trends.

Details provided regarding profits, provision and depreciation, for the 2,756 companies whose reports were received and analysed during the year 1954, are as follows (Table 15):

TABLE 15

Profits, Provisions and Depreciations

	Reports Published January—December, 1954	
	2,756 Companies	
	(£ *millions*)	
	Previous Year	*Latest Year*
Gross trading profit	1,501·3	1,662·9
Income from investments	96·0	108·5
Other current revenue	7·6	8·6
Non-recurring credits	76·3	66·2
Total income	1,681·2	1,846·2
Repairs and maintenance	9·2	9·9
Depreciation	249·4	280·0
Income tax (excess profits tax)	592·5	637·4
Profits tax	132·2	138·8
Directors' emoluments	50·8	53·4
Administrative charges, etc.	41·8	44·1
Contingencies, provisions, etc.	89·2	85·4
Pensions	21·0	22·4
Minority share in profits	18·1	20·0
Profits retained by subsidiaries	105·3	113·7
Debenture interest	32·8	36·4
Preference dividends	32·3	33·7
Ordinary dividends	170·1	203·6
Revenue reserves	114·8	148·9
Brought in (parent company)	278·0	299·7
Carried forward (parent company)	299·7	318·1

Balance sheet aggregates for 638 companies analysed during the fourth quarter of 1954 are given in the following form (Table 16 p. 88.)

The main data (for the same companies) are given for each of the 23 groups with a summary of total income and earnings for ordinary capital.

From time to time the accompanying article provides tables on similar lines dealing with such matters as changes in net worth, in stocks, or the rate of earnings on issued capital. Changes of capital, however measured (whether "nominal," "working," etc.) are, of course, relevant to a proper economic study of changes occurring in trading profits or costs.

The Economist pioneered in this field as long ago as 1909, when a profits computation was begun. This series, slightly revised in the years following the first world war, was continued until 1939. The series bears no relationship to that developed since, but details may be procured by researchers from *The Economist* library. In the later 30's it was made consistent regarding the treatment of income tax on a uniform net basis, which since the 1949 Act has eventually been generally adopted in company accounts.

2 (c). *The Inland Revenue Analysis*

But the most comprehensive record of the cost structure and changes occurring within British industries and trades is to be found in the analyses made in recent years by H.M. Commissioners of

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TABLE 16

Analysis of Balance Sheets Published in the Fourth Quarter of 1954

(£ *millions*)

	638 Companies	
	Previous Year	*Latest Year*
Capital (Parent Company):		
Debenture	158·0	168·8
Preference	182·6	186·5
Ordinary	354·7	400·0
	695·3	755·2
Reserves and Surplus:		
Capital reserve	157·2	160·2
Revenue reserves and carry forward	410·5	438·9
Total Capital, Reserves and Surplus	1,262·9	1,354·3
Outside interests in subsidiaries	26·2	30·3
Current liabilities and Provisions:		
Bank loans	63·4	63·7
Creditors, etc.	461·3	489·3
Future taxation	100·5	112·5
Other provisions	29·9	29·8
	655·1	695·3
	1,944·2	2,079·9

	638 Companies	
	Previous Year	*Latest Year*
Fixed Assets		
Land property and plant	922·6	1,019·1
Less Depreciation	268·7	308·1
	653·9	711·0
Trade investments	55·4	55·5
Intangible assets	50·0	51·2
Current Assets:		
Stocks	495·1	498·5
Debtors	307·7	341·8
Gilt-edged securities	35·1	40·0
Other marketable investments	115·3	119·1
Cash	231·8	263·0
	1,184·9	1,262·3
	1,944·2	2,079·9

Inland Revenue (13). Unfortunately no separation is attempted, or, indeed, is perhaps possible, between public and private companies; the data consist of straight aggregates using a large sample of company accounts which have formed the basis of assessment to income tax for the corresponding fiscal year.

Taking trading turnover, excluding "property and investment income", as 100, the major element of costs, trading profit (before and after depreciation allowances), total income, distributions, company taxation and balances are shown in percentage form. Companies are grouped broadly in accordance with what is believed to be their major activity under 28 industrial headings; but no data are given regarding shipping; banking; insurance and finance; undertakings operating abroad; water undertakings; or the few companies trading in agriculture.

Where large organizations contain separately taxed subsidiaries, these are separately allocated to appropriate groups, but many large organizations, taxed as a single unit, have substantial interests in more than one group, and the modicum of their trade, which should properly be allocated to some secondary group or groups, may be quite large and may need to be allowed for in considering the real cost structure of the latter. However, since it would be an impossible task, in any event, to attempt to isolate cost elements strictly appropriate to each economic type of trading, all that is required in practice is to construe the definition of each group with reasonable tolerance, and in the short term at least to assume that the same types of companies will be included in each group.

In the analyses for 1949/50 and 1950/51 (which appear in the annual report for the following fiscal year), the number of companies so sampled amounted to nearly 40,000, so that the great majority of types of private companies, as well as public companies, will have been adequately represented. The net trading profit, before taxation, appears to have varied from 7½ to 8½ per cent. of the global turnover:

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Ratio of Profit to Turnover

	No. of Cos. in Sample	*Net Trading Profit £m.*	*Turnover £m.*	*Net Trading Profit as % of Turnover*
1949/50	39,618	736	8,835	8·3
1950/51	39,822	755	10,157	7·4

(Net Trading Profit = trading turnover − costs + increases in stocks − depreciation allowances. Property and "franked" income excluded.)

These summary data are not given for 1951/52 in the report for the year 1952/53 recently published, while the coverage of companies analysed is less complete, and their number is not stated. The cost analyses for pre-war fiscal years given in the annual reports for 1950/51 were based on substantially larger samples.

The two earlier post-war samples of Schedule D returns were analysed further to provide some idea of the ranges and variation in the ratio of profit to turnover within groups; also to indicate changes in stocks, depreciation allowances and net trading profit, in total and for the various groups. One difficulty is that data are based on statutory allowances for depreciation and show no allocation to reserve (e.g. stock reserves).

Such data should reflect big changes arising from the incidence of recession or boom, and it is earnestly to be hoped that they may be continued. The 97th report of H.M. Commissioners of Inland Revenue (year ended March 31st, 1954) continues the series, but in this instance the analysis of costs and the figures for changes in stocks have been omitted. It is perhaps of interest to collate, as an illustration, the available data for one group, viz. vehicles. (Table 17.)

TABLE 17

Companies' Costs and Appropriation of Income

(Specimen Group)

Vehicles

	1937/38	*1938/39*	*1939/40*	*1949/50*	*1950/51*	*1951/52*
Turnover	100	100	100	100	100	100
Costs:						
(*a*) Materials	65·9	65·2	61·3	68·7	65·4	69·3
(*b*) Personnel	25·3	26·1	27·1	20·6	19·8	18·9
(*c*) Other	3·8	3·8	3·8	4·2	5·1	3·0
Increase in stocks	3·9	4·5	2·4	2·6	(−0·9)	0·7
Trading profit	8·9	9·3	10·2	9·1	8·8	9·5
Depreciation allowances	1·6	1·7	1·9	1·5	1·4	1·7
Net trading profit	7·3	7·6	8·3	7·7	7·4	7·8
Losses	—	—	—	—	—	—
Other income	1·7	1·5	1·6	0·4	0·4	0·3
Total income	9·0	9·2	9·9	7·9	7·7	8·0
Distribution (gross):						
(*a*) Dividends	4·1	4·6	4·7	2·1	1·9	1·9
(*b*) Loan interest	0·2	0·2	0·2	0·1	0·1	0·1
(*c*) Royalties	0·2	0·2	0·3	0·1	0·1	0·1
Profits tax	—	0·2	0·4	1·0	0·9	1·1
Income tax	1·2	1·2	1·9	2·1	2·1	2·4
Balance	3·3	2·7	2·5	2·6	2·6	2·5

2 (d). *Miscellaneous Sampling Inquiries*

As an example of the type of material collected from various sources which may shed light indirectly on changes in the general structure of companies as a whole, and either conflict with, or confirm impressions derived more subjectively in the course of an Investment Adviser's work, we may quote as a source the statistics relating to the balance sheets of 80 public companies (including

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their U.K. subsidiaries) which was submitted as evidence to the Royal Commission on Taxation of Profits and Income(14). This shows the broad changes in the structure of the assets which had occurred between 1938, 1945 and 1949. An attempt was also made therein to calculate what the current cost of replacement would be.

The general change in the make up of the available assets is shown, and the amount of the investments held, including those in unconsolidated subsidiaries, is stated. Total net assets changed from £447m. in 1938 to £809m. in 1949. The book value of the fixed assets, however, only rose from £134m. to £205m.; while investments were put at £101m. and £133m. respectively.

Now this material has only been procured at considerable expense and difficulty from a panel of firms whose co-operation was secured by the Federation of British Industries. Such a sample is, as they have carefully stated, more in the nature of a summary of cases. "Complete statistical accuracy cannot be claimed by these estimates. The conclusions, however, are in line with those drawn from other analyses and with those found in the reports of Chairmen of a wide range of public companies."

This again illustrates how essential it is to distinguish clearly between exact figures, "accountancy" figures, real or nominal monetary figures, statistically-controlled representative or specific estimates, and panel or special data; also how essential it is to stress constantly that in this field statistical data at present procurable can serve only as "indicators"—to be weighed and assessed against other impressions—rather than as precise indices or comprehensive statistics such as those which statisticians elsewhere are able to use. Still, an occasional thermometer reading is often all that the skilled practitioner needs to reassure his diagnosis, and is always valuable.

An analysis of current assets and liabilities for the years 1946 and 1949–50 in 1,500 small and medium-sized manufacturers was conducted by the British Bankers Association(15) and provided as evidence to the above mentioned committee. This work is of considerable interest, since information about the situation in small and medium-sized companies is rarely found separate from other material in which they are overshadowed by the figures relating to more substantial organizations.

These companies, for instance, were shown to have held some 6 per cent. of the book value of their assets in the form of marketable securities in 1946, but only 2½ per cent. in the fiscal year 1949–50.

Data regarding a carefully balanced but small sample of 24 companies were also given; the aggregate balance sheet and profit and loss account items are recorded.(16)

Similar data on private or small public companies will naturally be assembled privately by such bodies as the Industrial and Commercial Finance Corporation, whose services impinge on this field.

2 (e). *Commodity Price Indices*

(i) *The Times Monthly Review of Industry*, now incorporating the former London and Cambridge Economic Service, continues to provide concise tables dealing with world production and consumption of many commodities in world-trade which bear on certain types of investments (e.g. wool, tea, rubber). (The former London and Cambridge Economic service equity share index from 1913 to 1949 (yearly averages) is also usually recorded here; but Moody's share and yield indices are shown monthly for later years.)

(ii) *The Investors' Chronicle* provides series of commodity prices, showing changes during the current week, and previous month, and comparing with the corresponding period in the previous year.

(iii) Both *The Economist* and *The Financial Times* provide data on movements in selected commodity prices, such as rubber, tea, cotton and wool, which are closely watched by investors and investment advisers. These papers contain current data for specific industrial and financial groups of companies and securities in connection with the supplements which they publish from time to time. *The Financial Times* also publishes figures, and conveniently charts an index of Sensitive World Commodity Prices.

(iv) A service of prices and other data from the main commodity markets in the United Kingdom is also provided by the Exchange Telegraph Company.

Reporting is covered by special staff who have "Floor" rights (where there is a "Floor") although in many cases "official prices" are compiled by the governing bodies of the markets for use in press reporting and also for the purposes of the markets' own members. Most markets, however, are

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quite open to press reporters. Reporting for press purposes is mainly in the hands of the three principal agencies—Exchange Telegraph, Press Association and Reuters-Comtelburo. In general terms it can be said that Reuters Comtelburo undertake the coverage of London and provincial reporting (with the exception of Liverpool, which is covered by P.A./E.T.C.), and the transmission of the resulting reports is handled by the E.T.C. and Press Association Joint Service. Not all commodities are dealt in under open market conditions, the coal and iron and steel, silk and most fabricated manufactures being exceptions. The following are the principal open markets:

London

Baltic (covering spot floating cargoes in the principal grains, such as wheat, barley, maize and oats, and futures dealings in barley and maize.

Mark Lane Corn (largely milling grades and flours).

Cocoa futures.

Covent Garden Fruit and Vegetables.

Fish (Billingsgate).

Hay and Straw.

Metals (Non Ferrous) Ring market with two sessions a day, official prices and turnover information being officially compiled.

Potatoes.

Produce (covering foreign and colonial produce, excluding rubber, but including spices, fibres, etc.).

Rubber (continuous exchange facilities).

Provisions.

Wool (sales of Colonial wool).

Wool Futures (Ring market in futures opened recently).

Liverpool

Grain (wheat spot and futures, as from December, 1954; other futures may start later).

Cotton (full cotton market opened in May 1954).

Provisions.

Wool (Pakistan and Indian wools for carpet manufacture).

Bradford

Wool tops market.

There are various trading centres for home-produced wool, such as Exeter, Hawick, Bradford and Leicester.

STATISTICS OF INDIVIDUAL CONCERNS OR SPECIAL GROUPS

3 (a). *Historical Records*

(i) A number of Stock Exchange brokers and jobbing firms compile statistical data on various groups of companies and their securities as a service primarily to their clients. The strict rules, however, of the Stock Exchange do not permit a firm to circulate persons other than its own clients, and no individual "advertising" is permitted to the London brokers or jobbers.

(ii) A few private investment advisory services operate in this country. These often provide detailed records or charts of the movements of share prices, etc., for particular "lines" of securities. Such data serve as background material for a skilled assessment of market prospects, and for certain types of investment operations based more or less entirely on trend "analysis" or "systems."

(iii) *The Stock Exchange Year Book*(3), issued in two parts, in the summer of each year, records latest available details of the history, capitalization, subsidiary companies, annual high and low prices, dividend payments, etc., for every company, or other, security quoted on the London Stock Exchange. Many relevant data are included regarding that part of company capital which is *not* quoted (e.g. in wholly owned subsidiaries).

The Stock Exchange Year Book also contains details concerning the financing of municipalities and county councils and of overseas territories which are not readily collated elsewhere, e.g. loans

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outstanding and capital expediture, product of 1d. rate, etc., in the former cases; public debt and annual liability in respect thereof; loans raised and the way such monies are disposed of in various overseas countries; public income and expenditure (total and *per capita*) for many important countries. Another section is devoted to historic data on company registrations since 1862; changes in the Bank rate since 1887; the Bank reserve, proportion, and extent of "private deposits" weekly since 1947.

(iv) Moodys Services Limited issue to subscribers a basic review of some 60 leading industries and commodities at approximately half-yearly intervals. Economic appraisal of the outlook for the industry is coupled with tables and charts giving details of the financial results of representative companies over a period of years.

(v) Details of the profits, dividends and many balance sheet items for important overseas banks are procurable from an annual international banking supplement provided by the *Statist*.

(vi) *The Building Societies Year Book* and the *Insurance Directory and Year Book* provide consolidated and individual figures relating to companies operating in their fields, though, of course, the former type of company does not come within the orbit of Stock Exchange investment.

3 (b). *Latest Current Records*

(i) *The Stock Exchange Daily Official List*(1), and the Monthly Supplement, give for each quoted security the (daily) price quotation range, the prices on the day when last business was recorded (as shown by the bargain "marks") the rate of latest dividend, total for current year to date, a comparison with the previous year, and the date when the security went "*ex* dividend" (and also now the date of payment).

(ii) *The Exchange Telegraph Company Limited.*—The Agency has for many years provided a service from the "House" of prices and other announcements which are distributed by ticker-tape to newspapers, etc. See 1 (b).

They also provide a daily service to subscribers of the latest available material, with background, on individual companies on loose indexed cards. Series of cards giving official and other trade statistics are also sent out, as well as the data and special charts of *The Bankers' Magazine* Security Values Index. See 1 (g).

(iii) *Moodys Services Limited* also provide a service of individual company cards and regular series of loose leaf sheets providing latest available published economic statistics.

(iv) *Individual balance sheets, company reports, interim announcements.*—Many of these are printed in the advertising space of the press, and commented on by columnists. Although the first recipients of such data are naturally the shareholders, a copy of any balance sheet for a public company can be looked at, or a photostat procured, on payment of fees from the Search Room of the Registrar of Companies (at present in Bush House, Aldwych).

4. BROAD ECONOMIC DATA CONCERNING COMPANIES: INVESTMENT HOLDINGS: PERSONAL SAVINGS, ETC.

4 (a). *The Number of Limited Liability Companies and their Nominal Capital*

(i) The general annual report of the Board of Trade on Companies(17) provides details of the numbers registered each calendar year, whether public or private, together with the recorded initial nominal capital (some companies, however, have no share capital). Data are given separately for Scotland; England and Wales; a distribution table by size of nominal capital is included. Unfortunately, nominal capital, in the case of many private companies, bears no strict relationship to their importance or turnover.

The numbers extant on the registers at the year-end are also shown, for the two regions, together with the amount of paid-up capital. The following table shows the position* at various dates:

Great Britain	*1941*	*1946*	*1951*	*1952*
Number of public companies (000's) . .	13·6	13·2	11·6	11·6
Paid-up capital (£m.)	4,105	4,078	3,894	3,970
Number of private companies (000's) .	155·0	200·7	244·2	250·9
Paid-up capital (£m.)	1,948	1,923	2,267	2,330

* The figures exclude those in course of liquidation or removal from the registers, and those having no share capital.

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A number of private companies may be converted into public companies during the course of the year; it is also possible, but rarer, for public companies to be converted back to private status.

Approximately 60 per cent. of the 250,000 private companies are exempted from the requirement to file copies of balance sheets and profit and loss accounts with the Registrar of Companies. The remainder are mainly those in which public companies have a substantial interest or which are not of a "family business" type. Foreign companies with a place of business in Great Britiain are required to register documents under the Companies Act, 1948. The total recorded at the end of 1951 was 1,503; by the end of 1952 this had risen to 1,545, including 338 South African; 175 U.S.A.; and 162 Australian.

(ii) *The number of registrations of new companies in recent years* (*Great Britain*).—The report (17) provides also a statement of new company registration:

	(*1*) *Total Number*	(*2*) *With Share Capital Number*	(*3*) *Total Nominal Capital in col. (2)* (£*m.*)
1947	21,753	21,585	195·7
1948	16,344	16,191	117·8
1949	14,448	14,321	82·5
1950	13,906	13,746	74·5
1951	13,524	13,274	96·2
1952	12,296	12,170	52·0

Jordans Limited analyse regularly the type of trade or purpose for which new public companies are formed and provide a few more details concerning capital.

(iii) *Liquidations and bankruptcies.*—Major figures are available(17) for the number of liquidations begun and completed, for all companies operating in Great Britain and according to whether winding-up is compulsory or voluntary.

For details of *partnerships and private individuals* in bankruptcy, Board of Trade records exist and are occasionally reported in the Press; analyses issued more regularly but on private subscription, by *King's Mercantile Gazette Limited*, attempt to define more fully by broad trade groups.

4 (b). *The Number of Private Investors*

(i) Rhodes(18) has made estimates for the number of tax payers in a pre-war year who received income from "investments" (these, however, include by definition earnings from rent, property, etc.). He estimated some 290,000 were living solely on investment income, while some 1,800,000 added to their earned income in one or other of these ways. The percentage of total income derived from investment rose steadily as income increased.

(ii) Post-war comparisons within income groups or in real terms have been rendered difficult by the presence of inflationary conditions. The late Hargreaves Parkinson(19) analysed the size and type of share-holdings on the registers of 30 important companies which formed the base of *The Financial Times* Industrial Ordinary Shares Index. But the distribution of such equity shareholdings may, of course, only indirectly be related to the actual number of investors, and obscurity must remain regarding nominee holdings.

With the aid of formulae making use of estimates of the varying probabilities p_n that an individual holding "n" securities will appear in such a check register, Carter and Ellinger(20) attempted (1947), by a similar analysis of registers, to correct for the duplication present; by taking limiting "practical" values for the probabilities p_n and the proportions holding "n" securities, they estimated the number of private investors to lie somewhere between 1¼m. and 1¾m.

(iii) The Inland Revenue annual reports (13) provide analyses of the personal income derived from "investments" by sur-tax payers in various ranges of total income. All property coming into assessment for death duty in the year is also classified there into various types of securities, cash and property of different kinds. In 1951–2 some 77,000 estates with a net capital value of over £2,000 were so analysed; of the value of the property in these estates at that time some 20 per cent. was in government and municipal securities, some 29 per cent. in company stocks and shares (both public and private companies), while 13 per cent. was held in cash.

The stocks and shares will, of course, be valued at various prices according to the movement in Stock Exchange values during the period. These percentages cannot, without further information,

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be related to the holdings of shares generally. Attempts have been made(21)(22), based on mortality rates for different ages, to correct the picture; age and sex factors and the treatment of life assurance data are of considerable importance in such studies.

(iv) In a recent Inland Revenue report(14) a more comprehensive analysis of incomes was made for those amounting (net) to over £135 in the fiscal year 1949/50. The data are tabulated by region and by marital status. It makes a division between "earned" and "unearned" income, recording the number of cases and the amount of property income arising under Schedules A and B. It also gives the total amount of interest and dividends received, but the number of corresponding "entries" is not recorded. The total number of cases where "investment" income is recorded amount to 5¼m., while the number under Schedules A and B came to 3¾m., so that once again the number containing interest or dividends in income appears to be somewhat larger than 1½m. The total interest and dividends received in that year was £685m., but this will include holdings in private and public companies, family businesses and income on foreign securities or on shares not coming within the orbit of the Stock Exchanges.

In the £135–149 net income group the percentage of total gross income to be found in interest and dividends was as follows, by sex and marital status groups. The differences are interesting and important.

In the £135–149 net income group:

	England %	*Wales* %	*Scotland* %	*N. Ireland* %	*U.K.* %
Single males and widowers .	1·7	2·8	2·4	2·0	1·8
„ females and widows .	6·6	6·5	5·8	3·2	6·3
Married persons* . .	4·6	4·8	5·1	5·1	4·7

* Incomes here may refer to both together or separately according to the method of assessment.

In the £2,000–2, 499 income group:

	England %	*Wales* %	*Scotland* %	*N. Ireland* %	*U.K.* %
Single males and widowers .	28·0	16·8	30·5	42·3	28·0
„ females and widows .	77·0	69·1	63·0	63·5	75·1
Married persons* . .	18·6	16·8	18·9	18·2	18·6

* Incomes here may refer to both together or separately according to the method of assessment.

Unfortunately no data, by age-group, are by their nature available. These types of relationships have however considerable socio-economic value and applications.

4 (c). *Investments Held by Various Institutions*

(i) The annual return(23) of the Post Office Savings Bank gives details of the nature and nominal amount of the securities held by the National Debt Commissioners to meet liabilities to depositors,

(ii) The annual returns(24) of Trustees Savings Banks and Friendly Societies contain similar information.

(iii) So, too, do the annual accounts(25) of the National Insurance Fund (and related funds); but here, in addition, details are provided of the cost of purchases and the year-end market valuation.

(iv) The monthly statement(26) of the balances of the London Clearing Banks, issued by the Committee of London Clearing Bankers, indicates the total of their investments but does not analyse by type, except in so far as Treasury and other Bills are shown separately. Investments, apart from the latter, at November 17th, 1954, amounted (book value) to some £2,363m. It must be borne in mind, however, that this figure may neither represent the cost of purchase or the market value at that date, owing to the varying accountancy treatment of reserves. So too, with the individual balance-sheets(28), if at different dates.

(v) Insurance(28) and Group Pension Funds(29), Trade Unions, Building and Co-operative Societies, etc. hold considerable funds invested in securities. Many of these are referred to in other articles in this series. For the last three groups mentioned, data are derivable from statutory

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returns(30) to the Registrar of Friendly Societies, which are published in summary form annually and give series of comparable figures over the previous 5–10 years.

(vi) Details of the profits, dividends and many balance-sheet items for important overseas banks are procurable from an annual international banking supplement provided by *The Statist*.

(vii) Cuthbertson, in the *District Bank Review*(31), in discussing the supply of capital, estimates on the basis of available data the total of quoted securities in the hands of the institutions and the public respectively for end-years 1938, 1945 and 1950, and compares the estimate of the percentage of "safe" securities in the latters' holdings so found with that derivable from estate duty returns.

4 (d). *Distribution of Savings in Private Hands*

(i) In a 1948 sample survey(32) conducted for the National Savings Committee it was found that personal holdings of National Savings Certificates, together with Post Office and Trustee Savings Bank deposits were distributed approximately as follows:

Percentage of Adult Population	*Held in these Forms*
3·1%	Over £1,000
6·4%	,, £500
11·3%	,, £250
22·5%	,, £100
34·5%	,, £50
24·7%	Under £50

While some 40·8% hold no savings in these forms.

(ii) The same survey threw some light also on the spread of other types of institutional savings by "income" groups in 1947–8.

The percentage of the total number of individuals sampled who owned various types of investment is recorded below.

	Life Assurance or Endowment Policy %	*Co-operative Society* %	*Building Society* %	*Pensions Fund* %	*Savings or Loan Club* %
Total	53	15	12	11	10
By Income Group:					
Under £150	33	8	3	2	5
£150–£250	53	16	7	8	12
£250–£500	62	20	18	18	12
£500–£1,000	61	10	27	18	7
Over £1,000	59	3	21	12	—

(iii) In 1953 there were approximately 18 million holders of National Savings Certificates in England and Wales. The distribution by size of holding is not ascertained, but the Committee's monthly analyses(33) of units sold shows a usable consistency in pattern.

Certificates Sold (as Percentage of Total Value Sold)

	August, 1953 %	*October, 1953* %	*April, 1954* %
In 1 unit form	3·9	5·2	5·6
2–5 unit form	10·1	10·5	11·7
10–50 unit form	30·4	27·5	29·3
100 unit form	55·6	56·8	53·4
	100	100	100

Analysis of some 10,000 encashments of such certificates made recently by the Post Office showed that, although some 12 per cent. were cashed within 12 months, over 53 per cent. were held

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for the full 10-year life, and that only half of the latter were then cashed at full term (a considerable part of their proceeds may then again have been reinvested in newer issues).

(iv) *The Oxford Institute of Statistics Surveys.*—By far the most detailed and cogent picture of the general savings distribution among different classes of the community in recent years is provided in a series of articles(34) by Lydall and associates, reporting the results of pilot and full scale sample Foundation.

These articles also provide handy yearly time-series on changes in many of the personal and institutional savings data referred to above. The data are analysed by "income units", roughly corresponding to the Inland Revenue's "Incomes" for tax purposes, and not by family or household. The successful use of such a technique of personal interviews depends essentially on the extent to which unbiased co-operation is secured from all respondents. The gradients revealed in habits, etc., between classes, occupational types, etc., have proved generally acceptable and usefully applicable to many problems. About 2 per cent. of those interviewed in April/May, 1952 stated, for instance, that they had bought or sold some shares during the previous twelve months; this suggests a figure of perhaps 500,000 engaged in market transactions, or from 25–35 per cent. out of the estimated number of private shareholders.

(v) *Other "small savings" data.*—Annual reports (35) of H.M. Postmaster General trace movements between fiscal years in the total held on deposit, withdrawals and new deposits in the Post Office Savings Banks. Details are also shown of the medium term financing operation of the Post Office, by means of Terminable Annuities on a 19¾-year redemption basis.

Weekly changes in deposits are provided with similar information regarding National Savings Certificates, Defence Bonds and Trustees Savings Banks deposits in monthly returns(36) issued by the National Savings Committee. Unfortunately, as before, movements in these savings figures do not necessarily reflect the general movement among the savings of people of moderate or slender means. On the one hand, a great deal of such savings may accrue to people with substantial means, securing a sound, reasonably taxed investment in quite large amounts, and the general distribution of holdings seems to indicate that a substantial number hold the maximum to which any one investor is entitled. (See below.) On the other hand, many forms of small savings consist, for example, of "industrial" insurance contributions, holdings or mortgages in building and co-operative societies, etc., current and deposit accounts in banks, etc. Apart from studies of the annual changes in the various items, it is only possible to gauge subjectively the current trends. The annual amount of such savings again cannot be related directly to the net figure of personal savings which forms as yet only a residual in the National Income calculations (38).

It would be inopportune to discuss whether it will be possible to expand work on the lines of the surveys of the Oxford Institute of Statistics(34) to provide more frequent or more complete statistics of changes in this most vital statistic connected with the provision of new capital for risk enterprise or government, but the absence of regular comprehensive data regarding the general nature and movement of personal savings is one of the most serious practical economic gaps in this field.

National Savings Funds by Type

	End March, 1948 Percentage of Total	*October, 1953 Percentage of Total*	*October, 1953 Amount £m.*
P.O. Savings Bank (a) . . .	32·3	29·5	1,763
Trustee Savings Bank (a) . . .	12·6	16·1	963
Securities on Post Office Register (b) .	20·4	16·4	981
National Saving Certificates (c) . .	34·7	38·0	2,279(c)
	100	100	£5,986

(a) Sums due to depositors.
(b) Nominal value.
(c) "Accrued" "interest" is here included; £520m. at October, 1953.

Some 2 million people are estimated to hold Defence Bonds.

An index of "Accumulated National Savings," including interest accrued, in these forms at the end of each fiscal year from March 31st, 1936 to 1954, has appeared in the *Midland Bank Review.*(37)

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4 (e). *The Overseas Investments of U.K. Residents*

Estimates, continuing those made for pre-war years by Lord Kindersley, are made annually by the Bank of England(39), covering the nominal capital, dividends and interest earned on overseas investments of United Kingdom "residents" in securities "quoted on, unofficially dealt in or otherwise known to the London Stock Exchange." A number of unquoted United States and Canadian dollar securities are included for which exchange control operations provide basic data. The data amplify a part of the global totals, given in the National Income white papers, for property income secured from abroad.

Broadly speaking the basic figure is the proportion of capital held by United Kingdom residents in the United Kingdom registered companies operating almost entirely overseas. This is derived from that found in a large number of companies who co-operate with the Bank by reporting details to it each year. The activities of companies having both home and overseas trade interest are, however, excluded for technical reasons. The material provides, by type of security and type of company, by country of operation or residence, nominal share capital averaged over year-ends, dividends and loan interest involved, and any net capital repayment in the calendar year. The data take usually two years to collect and publish.

4 (f). *A Note on New Capital Issues*

Although dealt with in other articles, it may be helpful to provide some data on new capital issues in recent years as background to studies of savings for investment purposes.

The Midland Bank "new issue" statistics(49) have been compiled on a consistent basis over the entire period since 1919. The purpose throughout has been to record the amount of "new money" raised in the United Kingdom (other than borrowings by the British Government) by the issue of *marketable* securities.

New Capital Issues in the United Kingdom

(*Compiled by the Midland Bank Limited*)
(£000 *omitted*)

	1938	*1950*	*1951*	*1952*	*1953*	*1954*
January . .	7,465	10,995	28,089	5,587	29,808	3,345
February . .	19,248	9,690	9,923	56,379	11,670	93,937
March . . .	6,392	8,073	22,618	2,337	27,783	43,432
April . . .	5,114	6,669	1,639	157,743	136,402	9,338
May . . .	27,323	160,476	11,070	19,773	8,263	27,830
June . . .	8,509	5,931	11,208	16,590	18,205	15,510
July . . .	15,188	13,854	83,295	7,948	19,104	29,175
August . .	2,184	9,418	6,465	10,384	86,099	116,066
September . .	1,649	7,825	15,524	15,429	8,011	43,095
October . .	2,628	44,158	4,314	3,940	16,795	18,426
November . .	12,802	14,969	34,085	66,556	10,322	52,656
December . .	9,596	13,524	21,993	6,676	22,555	16 529
Other Items* .	—	7,350	1,766	1,142	1,014	1,791
	118,098	312,932	251,990	370,485	396,031	471,130

(* = Items not allocated to any month.

The figures *exclude* all borrowings by the British Government; shares issued to vendors; allotments arising from the capitalization of reserve funds and undivided profits; sales of already issued securities which add nothing to the capital resources of the company whose securities have been offered; issues in replacement of securities previously held in the United Kingdom; and private placings for which no market quotations are obtained. The figures are based upon the prices of issue. Shares in a number of iron and steel undertakings offered for sale by the Iron and Steel Holding and Realization Agency in 1953 and 1954 are not included.

5. GAPS AND PROJECTED RESEARCH

Reference has already been made to the difficulty of procuring comprehensive current data regarding the flow of savings in the economy (see 4 (d) (v)). Another gap which is being gradually

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closed, because of pressing current needs for information, is that regarding details of investment in the economic sense(58). A third concerns statistics to indicate the sources and sizes of the flow of dividend and interest payments from private and public companies (together and separately) into the private (personal) sector.

The division of certain official statistics into groups dealing with public and private companies separately would be helpful, but practical difficulties are formidable, as indeed they are in any attempt to obtain comprehensive figures in all parts of this field.

The absence of global data concerning credit operations, hire-purchase finance, etc.—the extent, as it were, to which consumers or industrial borrowers have pledged future earnings—is an important unmeasured influence in many business or economic problems.

The virtual equivalence of quoted debentures with bank overdrafts and loans is such that available data regarding fixed interest payments may frequently be deficient in many material respects when studies of the working of industry and business have to be made.

The National Institute for Economic and Social Research is at present engaged, as reported in *Accounting Research*(40), on a comprehensive study of monetary operations within companies. One of these investigations, into the "Finance of Public Companies"(40), will analyse sources and uses of funds in public companies during the post-war period, starting from published accounts as basis for deeper research with the aid of companies involved. A pilot study dealt with 54 companies in the hosiery and paper industries(41) which cover a substantial, if possibly, "unbalanced", part of the total trade turnover.

Some indication of the broad extent of trading each year in Stock Exchange securities is now procurable by inference and, in retrospect, from the yearly figures of government receipts from transfer duties which are on a fixed percentage basis.

Some indication of the volume of purchases made by institutions and private investors, even if only indirectly reflected by, say, their percentage distributions, by size of transaction, periodically procured, would be a valuable addition to our working knowledge. But, although many determined attempts have been made in recent years to bring United Kingdom material more into line with that available in the United States, there are few signs that the machinery could be set up at present.

It might be felt that the most promising line for progress would be through sampling methods, rather than through enumerations. The nature of material from companies, each, of course, with its own complex characteristics, is such that it is difficult to provide representative samples. If, for instance, every tenth company recorded in alphabetical order be systematically sampled, as has been occasionally attempted, the figures derived would vary substantially according to whether the letter "I" was covered or not, for this contains both Imperial Chemical Industries and the Imperial Tobacco Company. Stratification, therefore, has to be exceedingly fine, if theoretical objections to purposive selection are to be met.

In the field of personal interviews the difficulty of securing reliable material on incomes has always to be faced.

Unless greater initiative can come from the Treasury or Inland Revenue analysis of governmental or tax material (and there are grave drawbacks to this course) it is difficult to see where the finance of such research can be regularly secured. What is, in fact, everybody's business interest is unfortunately no one's particular responsibility. However, the growing realization of the need for reliable statistics in the above fields may lead, it is hoped, to a corresponding growth of co-operation within the "City," towards the ultimate procurement of the maximum that is practicable. Enough has been said in the foregoing pages to outline the formidable task involved in obtaining comprehensive and usable figures, and to stress that even if procured the inevitable gaps will continue to make the interpretation and use of statistics an art achievable only by constant application and experience in the business affairs to which they relate.

TEXT-REFERENCES AND ADDITIONAL BIBLIOGRAPHICAL INFORMATION

(A) *Publications issued under the authority or with the sanction of the Council of the London Stock Exchange:*

(1) *The Stock Exchange Daily Official List* (and "Monthly Supplement of Quoted Securities temporarily removed" therefrom), recently revised in details.

(2) Annual Valuation Statistics originally published, 1936 onwards, as a supplement to the *Annual Report of the General Purposes Committee*, and included later in the corresponding *Stock Exchange*

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Official Year Books(3). The present official title (1954) is "Statistics relating to Securities Quoted on the London Stock Exchange"; data now appear in a June or July edition of the *Weekly Official Intelligence*. This last contains details of dividend rates as they are announced and rates of tax.

(3) *The Stock Exchange Official Year Book*, issued annually in two parts, April and August, the second volume concentrating on the Commercial, Industrial, and Mines sections.

(B) *Other Publications or sources referred to in the text:*

(*Note.*—References to main financial newspapers and periodicals are generally omitted for brevity.)

(4) Moody's Investors Services Ltd., Arthur Street, London, E.C.4.

(5) *The Bankers' Magazine*, published by Waterlow & Sons Ltd., 85, London Wall, E.C.2.

(6) KENDALL, M. G. (1953) "Analysis of economic time series, Part I, Prices", *J. R. Statist. Soc.*, **116**, 11—34.

(7) In (5) above, monthly.

(9) Central Statistical Office: *National Income & Expenditure*, published annually. H.M.S.O.

(10) Central Statistical Office: "1946–52" published August, 1953; preliminary estimate for "1948-53". (Cmd. 9118) April, 1954; "1946–53", August, 1954 (used for the Table 13).

(11) *National Debt Return.* H.M.S.O. (Cmd. 8676 and Cmd. 8975 are latest available.)

(12) Bank of England. "*Report for the year ended 28th February . . .* ", annual.

(13) Reports of the Commissioners of H.M. Inland Revenue, for the year-ended March 31st, 1951—Cmd. 8436; March 31st, 1952—Cmd. 8726; March 31st, 1953—Cmd. 9030

(14) *Royal Commission on Taxation of Profits and Income.* H.M.S.O. Evidence on 17th day (August, 1952).

(15) —— Evidence on 6th day (November, 1951).

(16) —— Evidence on 13th day (July, 1952).

(17) Board of Trade: *General Annual Report on Companies.* H.M.S.O.

(18) RHODES, E. C. (1951), "Distribution of earned and investment incomes in the U.K. in 1937–38", *Economica*, **18**, 18–34.

(19) PARKINSON, HARGREAVES (1951), *The Ownership of British Industry.* London: Eyre & Spottiswood.

(20) CARTER, C. F. and ELLINGER, A. G., "An association of investors". Reprints of *Financial Times* articles.

(21) LANGLEY, K. M. (1951), "Distribution of capital in private hands 1936–8 and 1946–7", *Oxford Inst. Statist. Bull.*, **13**, 33. (The problem of allowing for price changes in real terms in such comparisons is discussed by one or two writers, e.g. Copeland and Martin: "The Correction of Wealth and Income Estimates for Price Changes", National (U.S.A.) Bureau of Economic Research, *Studies in Income Wealth*, Vol. 2, 1938).

(22) CUTHBERTSON, J. R. (1953), "The property holding habits of investors", *The Banker*, Vol. 101, No. 330–1.

(23) Post Office Savings Banks: *Account of Deposits Received . . . and nature of securities held . . .* " (annually). H.M.S.O.

(24) Trustee Savings Banks and Friendly Societies: *Accounts of Deposits Received . . . and Nature of Securities Held . . .* (annually). H.M.S.O.

(25) *National Insurance (and related) Funds, Accounts* (annually). H.M.S.O.

(26) *Monthly Statement of Balances of London Clearing Banks.* Bankers' Clearing House, 10, Lombard Street, London, E.C.3.

(27) Available on request.

(28) Insurance data: see HERBERT, A. G. and CLARKE, R. D. (1952), *J. R. Statist. Soc.*, **115**, 265–280; also *Insurance Directory and Year Book.*

(29) Group Pension Funds; PINGSTONE, G. W. (1952), "Industrial profits in the Welfare State", *Post Magazine and Insurance Monitor*, December 20th. (A later paper by a study group for the Institute and Faculty of Actuaries will be published in the Journal of the Institute, it is expected, as this article goes to print: Bacon, F. W., Benjamin, B. and Elphinstone, M. D. W., "The growth of pension rights and their impact on the National economy".)

(30) *Friendly Societies. Report of Chief Registrar* (Annual). H.M.S.O. *Building Societies Year Book* (Annual). Francy & Co. Ltd., Graham House, Tudor Street, E.C.4.

(31) CUTHBERTSON, J. R. (1952), "The supply of capital", *District Bank Review*, June.

(32) *The Public and National Savings*, 1948, Survey carried out for National Savings Committee by Social Surveys Ltd.

(33) National Savings Movement, 1, Princes Gate, London, S.W.7.

(34) LYDALL, H. F. (1951–54), *Oxford Inst. Statist. Bull.* (1951), September, November, December; (1952), March, July, November and December; (1953), February and March; June and July; October and November; (1954), April.

(35) *Post Office Commercial Accounts* for years (ending March 31st). H.M.S.O.

(36) Usually quoted in the daily press.

(37) *Midland Bank Review* (1950), November; (1954), November.

(38) SAUNDERS, C. T., "Some Problems in the Estimation of Personal Savings and Investments". *Proc. Manch. Stat. Soc. Papers*, November, 1954. Contains a valuable appraisal of the present position.

(39) Bank of England (1950). *United Kingdom Overseas Investment* 1938–1948, and subsequent annual supplements.

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(40) *Accounting Research* (1953), **4**, 104–105.
(41) LUBOFF, A. (1953), *National Inst. Economic and Social Research.* Reprint series 1. Published originally as an article in *Accounting Research* (40 above), pp. 291–317.

(C) *Sources not specifically referred to in the text, typifying those providing specialized data, as well as general material, on occasions.*

(42) "Holdings of British securities by Investment Trusts" (Appendix B to book by Henderson, R. F. (53).
(43) "Securities held by the Ministry of Health on behalf of the Hospital Endowments Fund at March, 1953, and assets realized during the year". *H.E.F. Accounts* 1952–3. H.M.S.O.
(44) *The Statist.* (Weekly.)
(45) *District Bank Review.* (Monthly.)
(46) *Stock Exchange Gazette.* (Weekly.)
(47) HOUGH, J. A. (1950), "Co-operative statistics", *J. R. Statist. Soc.*, **113**, 238–248.
(48) Articles in the *Oxford Institute of Statistics Bulletins*, e.g.:
PRESTON, E. (1950), "Personal savings through the Institutions 1937–49", **12**, No. 9.
SARGENT, J. K. (1952), "A rent, dividends and interest account for 1948", **14**, No. 1 (an appendix gives estimates of corporate holdings of British Government Securities at end 1948).
SEARS, D. (1950), "The levelling of incomes, **12**, No. 10.
GRIBBIN, T. K, (1953), "The use of statistics about savings", **15**, Nos. 6 and 7.

(D) *Other sources mainly concerned with New Capital or Investment*

(49) Midland Bank Ltd., monthly analysis of New Capital Issues, quoted in the press, and circulated on request. A yearly review is made in the February issue of the *Midland Bank Review*, which also gives the distribution of company issues as between debt, preference and ordinary capital. The yearly total is also divided by destination and type of borrower; and by industrial and other groups.
(50) Bank of England: *Report for the year ended 28th February* . . . (annually) contains statistical summaries regarding *United Kingdom Capital Issues.*
(51) HENDERSON, R. F. (1951), *The New Issue Market and the Finance of Industry.* Cambridge: Bowes & Bowes.
(52) *Economic Survey* (annually), for 1947 (Cmd. 7046); for 1948 (Cmd. 7344), etc.; for 1953 (Cmd. 8800). H.M.S.O.
(53) LAVINGTON, F. (1921), *The English Capital Market.* London: Methuen.
(54) *Report of the* [*Macmillan*] *Committee on Finance and Industry*, 1931. (Cmd. 3897.) H.M.S.O.
(55) GRANT, A. T. K. (1937), *A Study of the Capital Market in Post War Britain.* London: Macmillan.
(56) RADICE, E. A. (1939), *Savings in Great Britain* 1922–1935. Oxford Univ. Press.
(57) *Industrial & Commercial Finance Corporation*, annual reports.
(58) REDFERN, P. (1955), "Net Investment in Fixed Assets in the U.K., 1938–53" *R. Statist. Soc. J.* (in press).
(59) MACRAE, N. (1955), *The London Capital Market* (Staples Press). (This contains also some estimates of the division of holdings of securities as between institutional and private investors.)

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REVIEWS OF STATISTICAL AND ECONOMIC BOOKS

CONTENTS

	PAGE
1.—*Davies* (*O. L.*) (Ed.). Design and Analysis of Industrial Experiments	101
2.—*Blackwell* (*D.*) & *Girshick* (*M. A.*). Theory of Games and Statistical Decisions	102
3.—*Hoel* (*P. G.*). Introduction to Mathematical Statistics. 2nd ed.	103
4.—*Pearson* (*E. S.*) & *Hartley* (*H. O.*). (Ed.). Biometrika Tables for Statisticians. Vol. 1	103
5.—National Bureau of Standards. Applied Mathematics Series. Tables of Langrangian Coefficients for Sexagesimal Interpolation; Tables of Secants and Cosecants to Nine Significant Figures at Hundredths of a Degree	105
6.—National Bureau of Standards. Applied Mathematics Series. Statistical Theory of Extreme Value and some Practical Applications; Probability Tables for the Analysis of Extreme Value Data	106
7.—*Fox* (*L.*). A Short Table for Bessel Functions of Integer Orders and Large Arguments. *Miller* (*J. C. P.*) (Ed.). Table of Binomial Coefficients	106
8.—*Bliss* (*C. I.*) & *Calhoun* (*D. W.*). An Outline of Biometry	107
9.—*Eysenck* (*H. J.*). The Psychology of Politics	108
10.—*Edrick* (*H. L.*). Quality Control. 2nd ed.	109
11.—*Rios* (*S.*). Introduccion a los Metodos de la Estadistica. Part 2	110
12.—*Carter* (*C. F.*) & *Roy* (*A. D.*). British Economic Statistics	111
13. Toronto Meteorological Conference 1953, Proceedings	112
14.—*Roose* (*K. D.*). The Economics of Recession and Revival	113
15.—United Nations. The International Flow of Private Capital 1946–52	113
16.—*Stone* (*R.*), *Rowe* (*D. A.*) & *Corlett* (*W. J.*). The Measurement of Consumers' Expenditure and Behaviour in the United Kingdom, 1920–1938. Vol. I	114
Prest (*A. R.*), & *Adams* (*A. A.*). Consumers' Expenditure in the United Kingdom, 1900–1919	114
17.—*Richardson* (*J. H.*). An Introduction to the Study of Industrial Relations	116
18.—*Crawford* (*J. G.*) & *others*. Wartime Agriculture in Australia and New Zealand, 1939–50	118
19.—*Jefferys* (*J. B.*). Retail Trading in Britain 1850–1950	118

1.—*Design and Analysis of Industrial Experiments*. Edited by O. L. Davies. London: Oliver & Boyd, for Imperial Chemical Industries, Limited, 1954. xiii + 636 pp. 10″. 63*s*.

Dr. Davies and his colleagues at the I.C.I. have produced an authoritative account of the statistical aspects of the design and analysis of industrial experiments. Modern developments such as fractional replication and the work of Box and Wilson on the determination of optimum conditions are discussed thoroughly, and in fact a substantial part of the book is concerned with advanced designs. The book is, however, equally notable for its clear and helpful treatment of the more elementary designs and particularly for the excellent account of general principles. For this reason readers who think that they have no use for the more advanced designs should not be deterred by the formidable appearance of the latter part of the book; the first few chapters could be read with profit by anyone with a moderate knowledge of elementary statistical methods.

The application and analysis of each of the main designs is illustrated by a practical example drawn from the authors' experience. These examples are often of considerable interest. The book is non-mathematical but assumptions are thoroughly discussed and the general reasoning underlying the work is carefully set out; in this respect the book is a model of what a non-mathematical book on statistical methods should be.

It may seem unreasonable to conclude a review of a book as long as this one by suggesting further matter for inclusion, but there are one or two points of some importance which do not appear to be treated. First, there is the well-known principle that if R is a factor whose levels are a random sample from a population of levels and if A is any contrast (main effect or interaction) among fixed levels, then the error of A is determined by the interaction $A \times R$. This is frequently relevant; for example, when R represents observers, batches of raw material, etc., but I could find no description. Nor does there seem to be an account of what in agricultural experiments are termed split-plot designs; these are useful in industrial experiments with several stages of processing.

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Next there is the question of the adjustment of the results for concomitant variation, either by the construction of a suitable index, or by graphical methods, or by the analysis of covariance. There are two aspects of this. One is the possibility of increasing accuracy by correcting for variation that has not been removed in "blocking." The other is the testing of interactions of the treatment effects with the concomitant variation.

Then there is the basic assumption of additivity. There are again two aspects, the first being that interactions may sometimes be removed by a simple transformation, leading to a better understanding of the experiment; secondly, the basic methods of analysis assume that the quantity of most interest is the average over the experimental units of the *difference* that would be obtained by changing from one treatment to another. In the book transformations for removing non-normality and for stabilising variance are well described, but there is no account of transformations to induce additivity.

The book is excellently produced. It is an important addition to the literature and deserves a very wide circulation. D. R. Cox.

2.—*Theory of Games and Statistical Decisions*. By David Blackwell and M. A. Girshick. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd., 1954. xi + 355 pp. 9″. 60*s*.

This book is dedicated to the memory of Abraham Wald and its title establishes the connection with that discipline which was almost entirely his creation. It is thus natural to enquire after the relation of the present volume to Wald's *Statistical Decision Functions*, which is, at the time of writing this review, not more than four years old.

The earlier publication was the first exposition of these new ideas in book form, which bore some signs of quick drafting, as if impatience had compelled the author to make his results known as soon as possible. The new book is, to all appearances, a text-book, with "problems" after sections, though regrettably without solutions to them. It deals only with discrete probability distributions, except for some illustrations; yet it is about twice as long as Wald's book. There is no sign of hurry here, it is carefully edited. This does not mean, of course, that one must admire its design.

The subject-matter may be assumed to be known to our readers. The first two chapters describe the theory of zero-sum two-person games, which are not necessarily finite. The treatment is comprehensive and exceeds somewhat the topics required for statistical applications. This is welcome for its intrinsic interest and because it makes the exposition consistent. The proof given for the Fundamental Theorem is the simplest I have yet seen. In Chapter 3 we start with statistical games as a special type, and then read about basic probability concepts and learn the notation to be used. It is also here that the idea of sequential decisions is introduced. Chapter 4: Utility and Principles of Choice gives an excellent analysis of the objections to treating Nature as a deliberately spiteful opponent and justifies the concept of Bayes solutions, which take account of ancillary information that the statistician might have, while minimax solutions neglect it.

Chapter 5 is headed: "Classes of Optimal Strategies." Here complete and admissible strategies known from Wald's writings are defined and discussed. The connection between these and other concepts are exhibited and, in particular, sufficient conditions are given for the class of admissible strategies to be complete. These conditions are satisfied, for example, in fixed sample multi-decision games (see p. 199, 7.6.2.). Altogether nine "classes of optimal strategies" are listed: admissible class, Bayes class, minimax class, and various derivatives of these. Their set-theoretical relations are thoroughly investigated but "optimal strategies" as such are not defined. Unfortunately this may add to a confusion already existing in the terminology of this subject, because in other treatises (e.g. in J. C. C. McKinsey's *Introduction to the Theory of Games*) "optimal" stands for those strategies which are here, and in v. Neumann-Morgenstern's classic, called "good" and by Wald "minimax."

On p. 75 it is said that "the study of special classes of statistical games . . . will be undertaken in the last six chapters.' I think that the reference should be to the last seven. They deal with fixed sample and sequential processes, with sufficient statistics, estimation, and comparison of experiments.

The authors have given us a very thorough text-book, within self-imposed limitations, of a mathematical discipline about which many feel enthusiastic. Historically, it arose from an analysis of statistical situations. But has the connection been maintained? Some examples and problems are couched in statistical phraseology, but to one reader at least this seemed unconvincing and almost accidental. Moreover, the unifying role of statistical decision theory, which was for Wald the reason for its development, is never explicitly stated, let alone emphasized. The spirit of Wald's first chapter and of his earlier Notre Dame lectures is absent.

So much about contents. It would be unfair to readers not to add a few words about the presentation. This is formal and makes reading rather difficult. The assertion in the Preface that

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elementary analysis and algebra suffice to understand the text is surely disingenuous. What is most required is a taste for abstract formulation and a tremendous memory. How else could one remember all definitions and notations used? (Why not have, incidentally, an index of notations?) As a consequence, the book is less useful for consultation on some special issue than it might have been. Let us assume that we want to know the place of Neymann-Pearson theory in this wider framework. The index refers us to a "problem," which mentions a "convex hull of the set of attainable risk vectors for a game $G_u = (\Omega, D, P_u)$". We then remember that Ω is a parameter space of sample space $(z, \Omega—p)$, z being the space of outcomes of an experiment. All this is perfectly correct and unobjectionable, but one would wish for an occasional explanation in simple, if less rigorous language.

Could not somebody, some time, write for us "Statistical Decision Functions for Statisticians?" It would be a very useful exercise.

However, judged by the standards which the authors have set themselves, this is a very good book and an addition of fundamental importance to Messrs. Wiley's publications in statistics. Type, print and paper are excellent and a grumble about the price is, perhaps, too frequent nowadays to be made too eloquently.

S. VAJDA.

3.—*Introduction to Mathematical Statistics.* By P. G. Hoel. 2nd ed. New York: J. Wiley. London: Chapman and Hall. xi + 331 pp. 9″. 40*s*.

The first edition of this well-known book is reviewed in *J. R. Statist. Soc.* **110** (1947), 145. The new edition is about $1\frac{1}{4}$ times as long as the old; as well as the addition of new material there has been rearrangement so that general ideas about significance testing and estimation are introduced at an early stage.

Among the new sections are the following. A chapter on probability deals carefully with the laws of probability and with the definition and main properties of random variables. The treatment is based on the enumeration of equally likely cases rather than on limiting frequencies. The account of analysis of variance includes the estimation and testing of components of variance. Some of the work on analysis of variance seems artificial; for example, in a randomized block experiment comparing a number of treatments, the significance of treatment differences is demonstrated by an F test but there is no attempt to test or comment on the individual treatment differences. There is a long chapter on nonparametric methods. There are approximately 300 exercises for the reader; the answers are not given.

The mathematics is restricted to elementary calculus. The development is logical and the style very lucid.

My only serious criticism concerns the account of significance tests. There is an excellent introduction to the elements of the formal Neyman-Pearson theory, but the reader could very well get the idea that the way the tests are to be used in practice is this. A significance level α, nearly always 0·05, is chosen in advance of the data. If the sample falls in the critical region the sample is to be reported as "significant" (unqualified) and the null hypothesis rejected once and for all; if the sample falls outside the critical region the null hypothesis is accepted, there being a rigid dividing line between the two cases. This is surely the wrong attitude. In most applications the approximate level of significance attained should be reported and used as a measure of what evidence the data provide against the null hypothesis. The rigid scheme of acceptance and rejection contemplated in the Neyman-Pearson theory gives a vivid picture of what a particular level of significance means, but should not be taken as an instruction on how the theory is to be applied. In those applications where an irrevocable decision is called for, the choice of a critical region must depend on prior knowledge and loss functions and not on a purely arbitrary choice like $\alpha = 0{\cdot}05$; I could find no mention of either prior probabilities or loss functions.

Despite this criticism there is no doubt that the book is very valuable and the new edition is to be welcomed.

D. R. Cox.

4.—*Biometrika Tables for Statisticians*, Vol. I. Edited by E. S. Pearson and H. O. Hartley. Cambridge University Press, 1954. xiv + 238 pp. $11\frac{1}{4}$″. 25*s*.

This publication of a new collection of *Biometrika* tables is a welcome event. Since it was founded in 1901 *Biometrika* has contained a wide variety of tables of the mathematical functions occurring in statistical theory. Two separate collections of these tables, edited by Karl Pearson, were issued as Parts I and II of *Tables for Statisticians and Biometricians* in 1914 and 1931 respectively. They are now to be superseded by two new volumes edited by E. S. Pearson and H. O. Hartley of which the volume at present under review is the first. This volume includes 135 pages of tables and the editors have added to these over 100 pages of introduction.

The standard of the whole enterprise is such as one has come to expect as a matter of course in any *Biometrika* publication and a detailed description of its merits is not possible in a short

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review. I shall content myself with a few comments which will illustrate the general scope of the work, dividing these comments under the six heads the editors use in their classification of the tables. By this summary treatment, I must inevitably ignore many tables which readers may regard as being as important as the ones I do mention.

I. *Tables of the normal probability function.*—The most important tables of this function, which were calculated by W. F. Sheppard, are repeated again here. Tables entered with the probability integral as argument are given as well as those entered with the standardized deviate. The section is terminated by a table of functions of the normal curve specially useful in the calculation of the successive iterations to the maximum likelihood solution in probit analysis.

II. *Basic tables derived from the normal function.*—Probably the most ambitious tabling projects carried out under the direction of Karl Pearson were the calculation of the Incomplete Gamma Function and the Incomplete Beta Function tables. Karl Pearson early noted the importance of these functions; that, for instance, the Incomplete Gamma Function is directly related to the χ^2-integral required in testing goodness of fit and to the cumulative sums of terms of the Poisson distribution; and that the Incomplete Beta Function is related to the sums of terms of the Binomial distribution. He wished, also, to have comprehensive tables of these functions for use in fitting empirical distributions by means of his system of frequency curves. And he suggested that not only empirical distributions could be so fitted, but also theoretical distributions which have complex mathematical forms but whose lower moments can be calculated. When Sir Ronald Fisher developed the basic normal theory sampling distribution of the variance ratio and showed its applicability to the wide range of analysis of variance tests, it was seen that this sampling distribution was one of the transforms of the Incomplete Beta Function and again, therefore, the importance of having good tables of this function was stressed. The separate volumes of the Incomplete Gamma and Beta Function tables will always be a source of reference for the specialist. However, in the present section some smaller tables are given which will satisfy the requirements of most users.

Percentage points of the χ^2, t and F distributions are given in the form first proposed by Fisher to facilitate the application of the standard normal theory tests of significance. Percentage points of the Incomplete Beta Function are also given in a form applicable to the likelihood-ratio method of making statistical tests. In addition to these are included tables, to five decimal places, of the actual probability integrals of χ^2 and of t. The former is of particular interest since it is arranged in a convenient form for calculating the cumulative sum of terms of the Poisson distribution and hence supplements another table of individual terms of this distribution given later in the volume.

III. *Further tables of probability integrals, percentage points, etc., of distributions derived from the normal function.*—For samples from a normal distribution, the sample mean and variance are theoretically the best statistics to summarize the sample observations. In certain fields of application, however, it has become customary, for ease of calculation, or for other reasons, to use other statistics. Tables relating to the distributions of such statistics in samples from a normal population are contained in this section. For instance the probability integral of the range, W, is given to four decimal places for n from 2(1)20 at intervals of W equal to $0{\cdot}05\sigma$. Together with this is a table of percentage points of range. In a similar field of ideas are tables to assist in making quick and rough analyses of variance.

Reverting to normal theory statistics, there is also in this section a table for testing whether several variances are homogeneous.

IV. *Tables relating to certain discrete distributions.*—The individual terms of the Poisson distribution and the Binomial distribution, as distinct from sums of groups of such terms, are perhaps not often required. It is as well, however, to be prepared for the odd situation where they are and two tables in this section give this type of information. The first is the well-known table of Poisson terms due to H. E. Soper, covering the range $m = 0{\cdot}1(0{\cdot}1)15{\cdot}0$. The second is a table of the individual terms of certain Binomial distributions covering values of $n = 5(5)30$ and $p = 0{\cdot}01$, $0{\cdot}02(0{\cdot}02)0{\cdot}1(0{\cdot}1)0{\cdot}5$. This is but a small part of the possible range of values, but it is an important part, and in any case the calculation of isolated terms by taking logarithms is never difficult.

There are also in this section charts for the calculation of confidence limits for a true probability, p, from an observed fraction of occurrences, c/n. The introduction describes in some detail the interpretation of results calculated, using this chart and indeed, here as elsewhere in the introduction where other statistics are concerned, the care given to the description of the meaning of confidence limits is noteworthy.

Another topic dealt with in some detail in this section of the introduction is the testing of independence in a 2×2 table and an extensive table of critical values is included.

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V. *Miscellaneous tables.*—The tables of percentage points of the Incomplete Beta Function in both its basic forms, given in Section II, are designed principally with the application to analysis of variance tests in mind. In the present section is given a further table of percentage points of curves of the Pearson System (and not confined to Types I and VI) entered with arguments $\beta_1 =$ 0·00, 0·01, 0·03, 0·05, 0·10, 0·15, 0·2 (0·1) 1·0, and $\beta_2 = 1·8$ (0·2) 5·0. The actual percentage point is expressed as a standardized deviate. Accompanying the table is a chart showing which particular Pearson Type corresponds to a given (β_1, β_2).

Tables are also included in this section relating to the distribution of various rank correlation coefficients, and finally values are given of orthogonal polynomials up to the sixth degree for use in graduating equi-spaced data, covering $n = 1(1)41$.

VI. *Auxiliary tables.*—Some basic mathematical tables are included in this final section; for instance, n^2 and $\log n!$ are given for $n = 1(1)1000$; n^r (where $r = -1, -\frac{1}{2}, \frac{1}{2}, 3, 4, 5, 6, 7$) are given for $n = 1(1)100$. Also, by intervals of 0·01 in the unit range, are given values of $\Gamma(1 + p)$; $\log_{10}\Gamma(1 + p)$; $(1 - p^2)$; $\sqrt{1 - p^2}$; $(1 - p^2)^{-\frac{1}{2}}$; $p(1 - p)$; $\sqrt{p(1-p)}$ and $\{p^2 + (1 - p)^2\}^{\frac{1}{2}}$. These quantities are all much used in statistical applications.

It will be apparent from the above remarks that the constitution of the present volume as a whole differs very much from that of Part I of *Tables* for *Statisticians and Biometricians* which was issued forty years ago. This is as one would expect. Most of the developments of small sample theory have taken place in the meanwhile and the new collection mirrors this change. We concern ourselves much more to-day with the exact distributions of statistics in small samples, and in this connection have developed a certain rough philosophy of significance testing for which tables in percentage-point form seem entirely appropriate.

Quite apart, however, from significance testing, attitudes have also changed toward the basic problem of the graduation (or smoothing) of data. Certain procedures such as the systematic fitting of empirical frequency distributions by theoretical curves are now out of fashion, although rather surprisingly the systematic graduation of data in time series by curves such as successive order polynomials has not come in for as much criticism. Nor is it regarded as out of place to go to considerable trouble in finding successive approximations to maximum likelihood solutions of estimation problems as is done, for instance, in one of the popular methods of probit analysis.

One would, I think, be rash to assume that the impact of criticism will not produce further changes in the emphasis which statisticians will wish to place on different procedures, and even a reversion to older points of view is not out of question. Critics of established procedures will always have an easy task, for in the final analysis most methods depend, at least to some extent, on the concept of probability, and will always suffer, therefore, from the drawback that precise meaning cannot be attached to the different degrees on the probability scale. Nevertheless when the critics have done their worst, I believe that the advantages of having a solid corpus of widely accepted statistical theory, implying certain generally understood standard methods of calculation, will always be appreciated. Statisticians err chiefly when they claim too much. Calculations arranged in standard patterns can be very useful in forming judgments, provided no attempt is made to define too rigidly just how they should be used. We know exactly what has been done with a set of figures if some familiar type of numerical summary is presented. And, whatever theories we may have about statistical inference, it is unlikely that we shall lose interest in the sampling distributions of the statistics we calculate. The information on sampling distributions, in both percentage-point and probability-integral forms, which this volume provides, is unlikely therefore to become dated. And all the other aids to calculation and interpretation which it gives will always find favour with those who appreciate the accurate reduction of experimental results, however crude these results may be in themselves, or however uncertain the final conclusions that can be drawn from them. It seems likely that this collection of tables will surpass in popularity even its 1914 predecessor, and one hopes that the already evident signs that this may prove true will hearten the editors in their labours when compiling the promised second volume.

B. L. WELCH.

5.— *Tables of Langrangian Coefficients for Sexagesimal Interpolation.* National Bureau of Standards: Applied Mathematics Series, 35. ix, 157 pp. $10\frac{1}{4}''$. $2.

Tables of Secants and Cosecants to Nine Significant Figures at Hundredths of a Degree. National Bureau of Standards: Applied Mathematics Series 40. vi, 46 pp. $10\frac{1}{4}''$. 35*c*. Washington: Superintendent of Documents, 1954.

The existence of two widely used units of measurement of angle, the radian and the degree with its sexagesimal sub-division, has always been a cause of difficulty to the trigonometrical tablemaker.

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Radian measure naturally arises in theoretical investigations and tables with radian entry are fairly extensive. They have the merit that ordinary interpolation is easily performed as on any other elementary transcendental function.

Interpolation in tables with entries in degrees, minutes and seconds is more difficult if only because it is unfamiliar. The National Bureau of Standards volume of Lagrangian Coefficients for Sexagesimal Interpolation removes these difficulties and allows the familiar process of interpolation without differences to be applied to such tables. These tables give 8 place values of the Lagrangian Coefficients for 3(1) 6-part interpolation for a phase number of the form $p/3600$. ($p = 1(1)3599$). They are set out in 4 separate tables, one for each of the interpolation formulae. Each table consists of 60 pages giving on 60 rows the coefficients required. An accuracy of two units in the last place is claimed.

These tables will remove much of the difficulty of working in such an unsatisfactory radix system, but most statisticians will share my relief that this system of units plays very little part in our work.

An alternative system of units, intermediate between the sexagesimal system and the "natural" radian measure is to use degrees and decimal parts of a degree. This allows the practical man to work in familiar units and to reduce conversion from one system to the other to a mere multiplication. The N.B.S. have already produced a table of sines and cosines $0°(01°)45°$ and now they have provided a table of secants and cosecants. The tables, formed by division from the original 15-place tables, are given to 9 d.p.

Both these "utility" tables have excellent, concise, introductory accounts and their typography and layout maintain the usual high N.B.S. standard. K. D. TOCHER.

6.—*Statistical Theory of Extreme Values and some Practical Applications.* A series of lectures by E. J. Gumbel. National Bureau of Standards: Applied Mathematics Series, 33. viii, 51 pp. $10\frac{1}{4}''$. 40*c*. 1954.

Probability Tables for the Analysis of Extreme Value Data. National Bureau of Standards: Applied Mathematics Series 22. iii, 32 pp. $10\frac{1}{4}''$. 25*c*. 1953. Washington: Superintendent of Document.

Many readers of the statistical journals will have noted the steady stream of papers by E. J. Gumbel concerning the distribution of extreme values, and many will, like myself, have mentally docketed these as of theoretical value to be read when the need arises.

The National Bureau of Standards has now reproduced a set of lectures delivered by Gumbel which summarizes the results of a life-time's work. The first lecture gives the motivation behind his researches and shows that the practical problems of flood prediction and allied phenomena lead directly to a study of the relation between the distribution of individual values, the number of values involved and the distribution of extreme values. It also gives an interesting historical survey.

The second lecture develops the law of rare occurrences, introduces the concept of the return period and discusses the determination of these from practical data by the use of specially ruled paper.

The third lecture derives the exact distribution of extreme values and asymptotic expressions for them. A theory of types of initial distribution is developed wherein the limiting extreme distribution does not depend on the exact nature of the distribution of initial values, but only on its type, in particular, on its behaviour for large values of the independent variate.

The fourth lecture is devoted to applications.

The second volume gives a series of tables useful for the analysis of data concerning external data. These publications give us the opportunity to judge easily the value of this field of research.

K. D. TOCHER.

7.—*A Short Table for Bessel Functions of Integer Orders and Large Arguments;* prepared on behalf of the Mathematical Tables Committee of the Royal Society by L. Fox.. Cambridge University Press, 1954. 28 pp. 11″. 6*s*. 6*d*. Royal Society Shorter Mathematical Tables 3.

Table of Binomial Coefficients; prepared for the Mathematical Tables Committee of the British Association and the Royal Society. Edited by J. C. P. Miller. Cambridge University Press, 1954. viii, 162 pp. 11″. 35*s*. Royal Society Mathematical Tables Vol. 3.

The development of automatical computers has increased our power to produce tables. Indeed, the main limits on the size of any table now is the cost of printing the table and the weight of the resulting volume. This state of affairs is fraught with danger for the power to produce figures without labour is liable to lead, and some believe already has led to the production of figures without thought.

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It is therefore very encouraging to find that the danger has been resolutely avoided in these tables by Fox. These enable the values of the four Bessel functions $J_n(x)$, $Y_n(x)$, $I_n(x)$, $K_n(x)$ to be easily calculated.

$J_n(x)$, $Y_n(x)$ behave for large x as damped oscillations of period 2π with damping factor proportional to $x^{-\frac{1}{2}}$. Two correction factors P_n Q_n are tabulated as functions of $\frac{1}{x}$. Then

$$J_n(x) = \sqrt{\frac{2}{\pi x}}\,(P_n \cos\theta - Q_n \sin\theta)$$

$$\theta = x - \tfrac{1}{2}n\pi - \tfrac{1}{2}\pi.$$

$$Y_n(x) = \sqrt{\frac{2}{\pi x}}\,(P_n \sin\theta + Q_n \cos\theta)$$

The advantages of this tabulation over the direct tabulation of $J_n(x)$ $Y_n(x)$ are that the range of x can be extended to infinity by using the argument $\frac{1}{x}$ and that P_n, Q_n are interpolatable in that variable while J_n, Y_n are not.

Similarly $I_n(x)$, $K_n(x)$ behave like $e^{\pm x}/\sqrt{2\pi x}$ for large x and correction factors F_n, G_n are also tabulated. For large values of $n(\geqslant 10)$ $\log_e F_n$, $\log_e G_n$ are tabulated instead, as these are more easily interpolated. An accuracy of 9–10 significant places in the final functions (providing accurate enough trigonometric and extendential tables are used!) is claimed.

The production in such a compact form of such a large range table

$$\left[\frac{1}{x} = 0(\cdot 001)0\cdot 05, \quad n = 0(1)20\right]$$

is a very useful achievement for the ordinary desk computer, but this process of condensation at the expense of a little routine calculation is of the utmost importance for using these functions in an automatic computer. It is intolerably slow to calculate each Bessel function value required from first principles and it involves far more storage space than is usually available to store a complete table. The compromise of storing a short table and performing a simple calculation seems a very promising one.

An account of the method of computing and checking the table is given in the introduction. This account is a model of conciseness, while the method itself is as satisfyingly full of checks and counter-checks as it is reasonable to hope for in any calculation.

This is one of the first British tables to be produced by photo-lithography. The copy was prepared on an electromatic typewriter from punched cards. Since the calculations were not done on punched card machines this introduced an additional checking process, the cost of which must be offset against the reduction in printing costs.

The *Table of Binomial Coefficients* gives the exact values of $\binom{n}{r}$ for

(i)	$2 \leqslant r \leqslant \frac{1}{2}n \leqslant 100.$	
(ii)	$r = 2(1)12$	$n \leqslant 500$
(iii)	$r = 2(1)11$	$n = 500(1)\ 1{,}000$
(iv)	$r = 2(1)5$	$n = 1{,}000(1)\ 2{,}000$
(v)	$r = 2, 3$	$n = 2{,}000(1)\ 5{,}000.$

The calculation of the table was performed by workers in many of the mathematical laboratories of the country using Hollerith or National machines and has been checked by the standard procedures and against other known tables.

The work was financed by the Cunningham Bequest and the tables are primarily intended for workers in the theory of numbers.

K. D. Tocher.

8.—*An Outline of Biometry*. By C. I. Bliss and D. W. Calhoun. New Haven: Yale Cooperative Corporation, 1954. 272 + xvi pp. 11″. $4.50.

During eleven years of teaching statistics to biologists at Yale, Dr. Bliss has found it useful to provide lecture notes and copies of numerical examples. These have been constantly revised and extended, with the help of Mr. Calhoun, and this impressive book is the outcome. "Biometry" here means "statistical methods": non-statistical bio-mathematics is excluded.

The contents, and the order in which they occur, are interesting and unusual. After some useful notes on computing (Chapter I) the authors plunge immediately into the discussion of an

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experiment on taste discrimination, introducing the idea of a significance test. (The person whose claim is examined is perhaps less ambitious than his well-known predecessor; he only claims to distinguish between fresh and reconstituted skim milk.) Chapters III–V deal with the binomial distribution, χ^2 tests, and the analysis of contingency tables. Chapters VI and VII describe the normal distribution, with test and estimation procedures for its parameters, and Chapter VIII introduces interval estimation. Chapters IX and X on the comparison of two and several groups, respectively, are followed by an introduction to simple experimental designs (XI). Factorial experiments are described in Chapter XIII, the continuity being broken slightly by Chapter XII on regression. The remaining chapters are XIV: Bioassays from parallel regressions. XV: Associated measurements (including a section on the estimation of functional relationships). XVI: Two discontinuous distributions (Poisson and negative binomial.) XVII: Meeting the assumptions of the analysis of variance. There are 280 references (including some to papers published in 1954, only a few months before the book), 18 tables and 5 charts.

The general approach is non-mathematical. The text is written rather concisely in short numbered sections. This means that, although a surprising amount of material can be included, the exposition is on the whole not suitable for a first introduction to the subject. (To say this, of course, is not to criticise the value of the text as an adjunct to lectures, when it would enable the lecturer to concentrate on the teaching of principles rather than details.) On the whole the book would be found useful by the biologist who has previously acquired a background in statistics. I think the authors are right in hoping that "he will welcome its compact presentation and the inclusion of much specialized material". At times the search for brevity seems to lead to obscurity or (very occasionally) inaccuracy. The following quotation from p. 68 seems to me both inaccurate and obscure: "The variance of a sample of N observations is itself distributed normally with an error variance $V(s^2) = 2\sigma^4/n$, where n is the number of degrees of freedom in s^2. When σ^4 is replaced by s^4, $ns^2/\sigma^2 = \chi^2 \ldots$"

Two features of this book make it particularly attractive. The first is the superb collection of over 200 numerical examples, drawn from published work in many branches of biology. Some of these are fully worked out; others are left for the student to complete, the authors having done most of the routine computing of sums of squares, etc. These examples should be of great interest to all teachers of statistics. Example XVI–4*b*, on p. 222, uses the data of von Bortkiewicz on deaths from horse kicks per year per Prussian Army Corps, which are widely quoted as a classical example of the Poisson distribution. The analysis given here reveals the embarrassing fact, pointed out by C. P. Winsor in *Human Biology* in 1947, that highly significant differences exist between corps and between years. As Winsor says, von Bortkiewicz did not himself overlook the possibility of heterogeneity of this kind.

The other especially interesting feature of the book is the publicity given to various post-war methodological developments which are often ignored even in post-war textbooks. Some of these are straightforward solutions to commonly occurring problems, e.g. standard errors of treatment, comparisons in split-plot analyses (Taylor), and confidence limits for the abscissa at which a quadratic regression curve attains its maximum (Tukey). Besides these there are a number of short-cut methods of tackling problems for which the efficient solutions are well-known, e.g. the methods for analysing group differences based on ranges instead of variances (Hartley, David and Tukey). Incidentally, many of Tukey's results have not previously been published formally.

The methods for the estimation of functional relationships, already referred to, must, I think, be used with caution on biological data. In this field there are usually no grounds for believing that the observed pairs of values deviate by random errors from pairs of true values falling exactly on a straight line. Example XV–2*b* on p. 199, for example, gives the observed counts, on a transformed scale, of two species of plankton in successive hauls. These measurements are assumed to deviate, with equal variances, from "true values" which are exactly linearly related. I do not know how appropriate this model is in this particular situation, but I suspect that it will not frequently be suitable in biological work.

An Outline of Biometry is printed in a limited edition of 400 copies, by the multilith process (which looks like very good typescript). It is available either in wire-stitched form, which does not open flat, or punched for use in standard three-hole loose-leaf binders.

P. ARMITAGE.

9.—*The Psychology of Politics*. By H. J. Eysenck. London: Routledge & Kegan Paul, 1954. xvi + 317 pp. $8\frac{3}{4}''$. 25*s*.

Professor Eysenck has attempted to write a book about modern developments in the field of attitude study, a book which would be intelligible to the layman without special training in psychology or statistics. He accepts G. W. Allport's definition of an attitude as "a mental and neural state of readiness organized through experience, exerting a directive or dynamic influence

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upon the individual's response to all objects and situations with which it is related", and holds that an attitude cannot therefore be directly observed, but must be deduced from other events which are directly observable. The attitudes of which he writes are those of Conservatism, Radicalism, anti-Semitism, etc., and he attempts to relate these to antecedent conditions such as income, age, sex, personality and education and to consequent events such as voting, verbal and non-verbal behaviour, etc.

Many of the investigations quoted make use of correlational methods. Eysenck takes a correlation coefficient as implying causation and appears to regard a tetrachoric coefficient as being equivalent to a product-moment one. However that may be, he rarely indicates what sort of coefficients he is quoting or, indeed, what sort were used in the factor-analytic studies reported. This could be misleading to a layman who accepted uncritically the conclusions presented. For example, on p. 18 he quotes a tetrachoric coefficient of ·76 between social class (as estimated by interviewers of the British Institute of Public Opinion) and social status (as estimated by interviewees' own opinions of their status). He concludes that while "status is obviously the most important determinant of class consciousness, it is clearly not the only one". However, he corrects this coefficient for "attenuation", using a "reliability coefficient" *obtained in a different study in a different country*, and quotes the corrected coefficient as ·95, which, he concludes, suggests that "social class estimates are determined almost completely by social status" (p. 20). This, of course, is not a vital conclusion, but it does throw doubts on the validity of the many experimental results given in the book—doubts which could be resolved only by consulting the original papers referred to.

In the second chapter the difficulties and pitfalls involved in public opinion polls are discussed under the headings of sampling, the wording of questions and problems of interviewing. Eysenck concludes that "public opinion polling by single questions is of very doubtful value indeed for the ascertaining of social attitudes", and states that the only way out is by the construction of scales of measurement. Fundamentally such scales consist of lists of questions assumed to "measure" a particular attitude. These questions are answered by members of the public and the answers assessed and scored by the investigators. By the use of such scales the author claims that two "measures" or "dimensions" of social attitudes have been discovered. The first is a measure of the Radical-Conservative continuum, or the *R*-factor, and by a somewhat circular argument it is concluded that self-confessed Socialists score highly, Conservatives lowly and Liberals intermediately on the *R*-scale. The other dimension is the *T*-factor. This contrasts "tough-mindedness" with "tender-mindedness". The author takes over these terms from William James to describe what he calls the "practical-theoretical dichotomy". Later the terms are said to be highly related to "extraversion" and "introversion" and tough-mindedness to be associated with dominance and aggression. It is doubtful whether either James or Jung would have sanctioned this usage of the terms they introduced. The *R*-factor is claimed to be a major dimension of social attitudes, but the *T*-factor is essentially a *projection* on to the field of social attitudes of certain fundamental personality traits.

From this stage the double dichotomy appears to be taken for granted and a good deal is written about tough-minded Conservatives and tender-minded Socialists. The author promises "proof" of the validity of these distinctions and the relationship between them, but it appears to the reviewer that the word "proof" is used rather loosely. For example, a very great deal is written about the results of an experiment on attitude rating made on a group comprising 43 working-class Communists, 43 working-class Fascists and 86 soldiers who constituted a "fairly random sample of British working-class males". In Table 1, p. 15, the author quotes data to show that 99·3 per cent. of recorded votes in 1951 were Conservative, Socialist or Liberal. It is difficult, therefore, to see what application deductions from these tiny extreme minority groups can have on political attitudes in general.

Eysenck then attempts to relate the *R*- and *T*-factors to modern theories of learning, chiefly Hull's theories. He says that the two types of neural modification called *learning* and *conditioning* account respectively for the *R*- and *T*-factors. This conclusion is admittedly speculative, but the chapter devoted to its discussion (entitled "A Theory of Political Action") is perhaps more interesting to read than the mass of rather dreary material comprising the bulk of the book.

In the reviewer's opinion a minority of psychologists will find this book interesting, most statisticians will be sceptical and politicians will probably find the main conclusions much more amusingly presented by W. S. Gilbert in the Sentry's Song in *Iolanthe*. E. G. CHAMBERS.

10.—*Quality Control*. By H. L. Edrick. 2nd ed. New York, The Industrial Press (Brighton, England: Machinery Publishing Co.), 1954. 181 pp. 9″. 37*s*. 6*d*.

The keynote of this book is found in the sub-title—"simplified for practical application". The "simplification" of statistical quality control has been taken to such a degree that instruction in

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basic theory has almost disappeared and the book is essentially a set of instructions how to install and run quality control charts and statistical sampling plans, including the Wald sequential scheme. One even has the feeling that the author wants the engineering plant inspectors, for whom the book is intended, to accept the simple rules of procedure that are prescribed without worrying about statistical principles. "Frequency distributions are somewhat wearisome to construct", he says and states in the first paragraph of Chapter 12, "Statistical Basis of Modern Quality Control"—note that theory first appears in Chapter 12—"a reading of this chapter is not essential for the practical application of scientific quality control". Chapter 12 is actually concerned with the theory behind statistical sampling, with operating characteristic curves for several schemes; Chapter 13 deals with the theory of average-standard deviation quality control charts, and Chapter 14 discusses the normal distribution and the use of the coefficient of variation.

After this brief section on statistical theory, the author returns to sets of instructions for various special types of control chart, including that using "compressed limit" gauges, developed by D. J. Desmond, to whom he pays tribute. In Chapter 17 on percentage defective and number defective charts the reference to theory is extremely brief, and the binomial distribution is mentioned, but not the Poisson distribution.

The practice recommended for Q.C. charts, is that laid down originally by Dr. Shewhart, adopted as standard in North America, and is different in detail from that which has become standard in this country. The differences are not great, but the British reader of any American work on Quality Control should be made aware that they exist.

The book concludes with a chapter "Analysis of Variance". The author would have been wiser not to attempt to deal with such a complex subject in such brief space.

If there is a third edition of "Quality Control", it is suggested that the author be less afraid of frightening his readers, and give an enlarged section on theory at the beginning, so that the engineering inspector having understood why he should use statistical sampling and quality control arrives at the competent working instructions. A useful extension would be the inclusion of a section on the application of the theory of runs to quality control charts. A. W. SWAN.

11.—*Introduccion a los Metodos de la Estadistica.* Part 2. By Sixto Rios. Madrid, 1954. viii + 242 pp. 8½

The author of this book is the director of a school of statistics which has been organized in the University of Madrid since the last war. The word "school" should, in this context, be understood to mean a teaching establishment rather than a research group, and it is of interest to see how energetically Professor Rios assists his students in catching up with that statistical knowledge to which British and American scholars have, as yet, made significantly more contributions than his fellow countrymen. Spanish translations of fundamental tracts written in English have been and are being prepared, and personal contacts are being nursed. The present book should be judged against this background.

The volume now under review is the second part of a course in mathematical statistics. (The reviewer has seen a mimeographed edition of the first part, which has not been reviewed in this *Journal*.) It deals with a number of subjects not often found in text-books. The presentation of the theory of estimation and of testing hypotheses follows familiar lines, as do the chapters on quality control, design of experiments, multivariate analysis and on small samples. But there are also chapters on decision functions, sequential analysis, non-parametric distributions, time series and stochastic processes. Somewhat surprisingly, the last mentioned chapter starts off with axiomatics of probability theory. The exposition is, of course, elementary and the more "modern" chapters in particular are rather sketchy, but they contain just the right dose for a first treatment.

There is nothing in the book which English readers could not learn from works in their own language, and so we need not be disturbed by the many misprints, not only in the Spanish text, but also in the bibliography which contains, naturally, many English titles. It is subdivided into "General books" and "Special books", the latter referring either to various chapters or to subjects. Some have no discernible connection with the main text and the selection is, in any case, not that which the reviewer would have made. It is more a testimonial to the author's enthusiasm than to the relevance of the reference.

Enthusiasm is also the keynote of an Appendix on "Operational Research and its Industrial and Military, etc., Applications." This is based on lectures given by the author and contains an outline of the history of Operational Research and an account of a visit to Great Britain. The examples are those familiar from talks, lectures and books, and have a strong flavour of advertisement. Gratifying as it is to find British war time contributions given their due credit in a Spanish book, I believe that the inclusion of such an appendix of 40 pages in a book of about 240 is a mistake. This review is not the place to discuss the relation between statistics and operational research, but the latter is very definitely not a part of the former (nor does the reversed position

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hold, of course.) One would wish that a textbook on statistics took it for granted that this field was of intrinsic interest, independently of possible applications to branches which are but vaguely defined.

In spite of such objections which, it will be noted, refer to an extravagance rather than to the design of the book, Professor Rios is to be congratulated on an achievement which, by the standards he has set himself, must be deemed to be successful. S. VAJDA.

12.—*British Economic Statistics.* By C. F. Carter and A. D. Roy. London: Cambridge University Press, 1954. vii + 188 pp. 9½″. 21*s*.

The Executive Committee of the National Institute of Economic and Social Research initiated, in November, 1950, a project called "An examination of British Economic Statistics". This was intended to investigate the statistical information (*a*) required for or (*b*) actually used or available for, the formulation of economic policy in the United Kingdom. The survey was carried out by Professor C. F. Carter and Mr. A. D. Roy under the direction of a committee consisting of Professors R. G. D. Allen, A. K. Cairncross and E. Devons, Sir Donald MacDougal, Mr. W B. Reddaway, and Mr. R. Stone. The book under review is the result of this work.

It can be said at the outset that, within the limitations imposed by the origin of the enquiry, the survey has been well done. The authors have completed their extremely difficult task most competently. Their approach has been eminently balanced and they have successfully avoided the two opposing dangers facing any examiner of economic statistics. It would have been so easy either to condemn the statistical approach outright or to argue for a vast extension in the provision of statistical information bearing on economic policy. Statistical material, like any other kind of knowledge, may be partial and incomplete. Its use may be subject to endless qualifications. This is no reason, however, to reject or ignore any light, slight though it be, which statistics can throw on a problem. Equally truly we can never expect to find the complete answer in the statistics. We shall never be in the position of having the perfect model of the economic system.

The book consists of a very brief and rather superficial introductory essay on the relationship between statistics and economic policy; a series of case studies in particular fields (Housing, Coal, Development Areas, Agriculture, Balance of Payments, General Balance of the Economy), and, finally, a discussion of the lessons learnt from these examples under the headings of quality, presentation, and organization. A very convenient arrangement but, in execution, not completely satisfying. This may be, as suggested earlier, a result of the limitations imposed upon the authors by the fact that they were commissioned to write a book for the National Institute which could presumably be sold at a reasonable price. In fact there is scope in the examination of British economic statistics for a survey much more thorough, detailed, and of greater length than could reasonably be compressed into a potential best-seller.

Whatever the reason, an introductory chapter on the whole position of statistics in the determination of economic policy, of but seven pages, can hardly be considered adequate. Again, while the case studies are admirable as far as they go, there are some amazing omissions. Surely the majority of critics, when their attention is directed to British economic statistics, think of the subject in terms primarily, of the Censuses of Population, Production, and Distribution; Manpower figures; Foreign Trade statistics; National Income and Expenditure estimates; Index-numbers of Prices, Production, Volume of Trade, etc. In their study of the General Balance of the Economy, Professor Carter and Mr. Roy assume implicit dependence on the National Income estimates, but as for the rest they receive only minor references. Certainly there is no comprehensive appraisal of their uses in and relationship to the determination of economic policy.

There is much good sense and reason in the last section of the book on quality, presentation and organization, but in some respects an apparent air of complacency rather mars the treatment. Particularly in matters of organization has there been a clear reluctance to criticize the *status quo*. Criteria of quality, too, have been rather narrowly specified. There may be fully efficient collection of statistics with no deliberate distortion, no lack of response or responsibility on the part of informants, negligible sampling errors, and yet the final figures may be less than satisfactory because of some peculiarity of definition, inadequacy of scope, or lack of comparability and consistency with other material. It is good that the appalling dearth of explanation, description and comment when British economic statistics are published should be deplored. But it is regrettable that the authors did not discuss in some detail the serious implications of this when, for example, statistics relating to the same concept from different sources exhibit inconsistencies. Indeed, it appears to be implied on p. 156 that there is ultimate reconciliation between Ministry of Labour and Census of Production returns in relation to employment. In fact there are not inconsiderable discrepancies not only between Ministry of Labour and Census of Production employment data but also between either of these and the industrial tables of the Census of Population.

In conclusion it must be admitted that few of the above criticisms could be met without increasing

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length. Again it might be said that some of the remarks are not relevant to the central issue of statistics in economic policy. On the other hand, it is clear that Professor Carter and Mr. Roy have found it necessary occasionally to go beyond the confines of a narrow interpretation of their terms of reference. But in producing a book of 188 pages on this subject they have steered a balanced course with considerable skill, ingenuity and not a little tact. K. S. LOMAX.

13.—*Proceedings of the Toronto Meteorological Conference* 1953 held by the American Meteorological Society and Royal Meteorological Society. London: Royal Meteorological Society, 1954. iv + 294 pp. 10″. 30*s*.

This publication is a report of the first large-scale joint meeting of the American Meteorological Society and the Royal Meteorological Society of Great Britain, the Canadian branch of the latter acting as hosts. The meeting is reported with a very fair degree of completeness; some 45 of the papers read at the nine meteorological sessions being reported in full and the remaining few appearing as summaries.

Perhaps the main interest of the volume is in the large range of subject-matter it contains. The opening symposium deals with "Ozone and the High Atmosphere," i.e. it is concerned with heights of 20 to 80 km. In these layers of air, observations are largely indirect. The spectral method, described by Goody and Walshaw, of determining height (or pressure level) of ozone forms a link with the succeeding symposium—on "Radiation and other Energy Transformations." Some consideration of radiation occurs also in "Arctic Meteorology" and in Hewson's paper on "Atmospheric Pollution" in the symposium on micrometeorology. Of the other sessions, four deal with various aspects of that part of the upper air (below 20 km.) in which observations of pressure, temperature and wind are made daily in many parts of the world. These aspects are "high-level forecasting", "the general circulation", "modern cyclone theory" and "cloud physics and induced precipitation". The remaining session, a "Panel Discussion on Climatic Change", is of necessity confined to "surface" data; for actual observations of temperature appear to go back to 1700 A.D., and geological and historical evidence carry the records at least 200 years further back, even in the New World, though somewhat doubtfully. Climatic change is a subject fascinating not only to climatologists; and Manley, Longley, C. F. Brooks, Ives, and Ovey, with his note on the study of cores taken from deep-sea sediments, all give interesting accounts.

The plates include (in the section on the high atmosphere) some striking photographs of noctilucent clouds taken by J. Paton of Edinburgh University. These clouds, occurring at 80 km, are observed only on summer nights and in latitudes 45° to 62°.

On turning over the pages of the report of the Toronto conference, the reader is struck by the paucity of applications of statistical methods; but the statistical approach is not entirely lacking. Examples occur in the section on cloud physics, in "Observations and Measurements on Natural and Artificial Rain from Convective Clouds" by Byers and others (University of Chicago) and in "The Characteristics of Super-cooled Clouds during Canadian Icing Experiments, 1950–53" by Pettit; and statistical models of atmospheric transmission are included in the theoretical discussions by Godson (Canada), Kaplan (U.S.A.), Walshaw and Goody (Britain) and Plass (U.S.A.) on radiation. In the section on high-level forecasting we hear from Sutcliffe and Sawyer that forecasting of wind in the stratosphere (at 16 km, for example) has proved unsuccessful by the contour-chart technique used for lower levels; a statistical method suggested by Durst, in which forecast and actual wind vectors are related by means of a linear regression equation, is found to give much smaller errors. The statistical method takes note of day-to-day "persistence". Other papers in the same section treat of "jet streams", aircraft exhaust trails and high-level turbulence in clear air.

Papers very readable to non-physicists include, in micrometeorology, Thornthwaite on "Topoclimatology" and at least part of Hirst, Long and Penman on "Micrometeorology in the Potato Crop" and, in Arctic meteorology, Sverdrup's introductory article and Rae's account of "the problem of establishing and maintaining weather stations in the Arctic". "Meteorologists", he says, "have a tendency to treat weather observations merely as so much grist for the mill of the synoptic weather chart. When they see . . . symbols . . . around . . .. Resolute, for example, which show that the pressure is falling and the wind is increasing, they form no mental picture of a parka-clad observer leaning into the blizzard as he stumbles over snowdrifts to reach the thermometer screen".

The inclusion of papers by such well-known names as Berry, J. Bjerknes, C. F. Brooks, Byers, Charney, Landsberg, Namias and Thornthwaite from America; Bannon, Eady, Goody, Normand, Robinson, Sawyer, Sheppard and Sutcliffe of Great Britain; and Godson, Hewson, Longley and Andrew Thomson from Canada ; as well as Sverdrup from Norway and Liljequist from Sweden; is sufficient to stamp the Toronto Conference as authoritative meteorology. The publication, too,

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of the *Proceedings* attains the usual high standard of the Royal Meteorological Society. The diagrams are clear and the type is very pleasing to read. None of the book is cramped and the whole is light in weight and neat in size.

This volume does not by any means provide the layman with an exhaustive account of the activities of professional meteorologists; but it does "high-light" some aspects of work proceeding in various branches of meteorology both sides of the Atlantic. The layman will find it an eye-opener, the meteorologist a tonic.

N. GOLDIE.

14.—*The Economics of Recession and Revival.* By K. D. Roose. New Haven: Yale University Press (London: Geoffrey Cumberlege), 1954. xi + 280 pp. 9¼″. $4.

By May, 1936, the United States had failed to revive fully from the great depression of the early 'thirties. In that month some 9 million people were unemployed; real incomes, industrial production, profits and prices were less than in 1929. Improvements in the economic indicators throughout the remainder of 1936 were soon followed by signs of impending difficulty in the first five months of 1937: during the summer there was a serious decline in business activity; and from September to June of the following year the American economy underwent a decline whose severity is without parallel in that country's history. What went wrong?

Professor Roose is not trying to "sell" yet another theory of the trade cycle. His aim is to test business cycle theory empirically against American experience in 1937–38. The data on this period are more plentiful than for any previous period of decline in the United States, yet they are far from adequate. Much of the book consists of a detailed examination of seven groups of economic indices covering the over-all performance of the economy, financial investment, the money market and banking system, price-cost relationships, employment and unemployment, consumption factors and capital formation. The reviewer had neither the time nor the knowledge to appraise this analysis. Indeed, it makes rather dull reading. One is constantly tempted to turn on and find out what happens at the end of the story. What does happen is that when business cycle theory is tested empirically, business cycle theory itself dissolves and is no more. We are left with just a fluctuation. The recession and revival of 1937–38 was not a phase in a cycle; it was a unique event brought about by a grouping of circumstances which had not occurred before and which is unlikely to occur again. There is no single or simple explanation of any business fluctuation; the causes of any fluctuation are complex and multiple.

The prescription which emerges from Professor Roose's study is that other fluctuations of the past should be studied. Although we can no longer hope to control the economy merely by locating ourselves accurately at the right point on a pattern of cyclical development, we can learn from the past. And one of the lessons we learn from the particular piece of the past that Professor Roose has studied so carefully is the need for adequate data. It is a chastening thought that because there was no series of figures on net government contributions to income in 1937–38 "most policy-makers and economists were unaware that the government was acting as a deflationary agent throughout 1937. In fact it was not until almost a year after net government contributions had begun to precipitate decline that professional economists generally learned of this development".

P. A. DANIELL.

15.—*The International Flow of Private Capital* 1946–52. New York: United Nations, 1954. v + 61 pp. 9″. 3*s*.

This is the second report on international capital movements which has been prepared and published by the secretariat of United Nations. The first, entitled *International Capital Movements during the Inter-war Period*, covered the years 1919–1938. The story is taken up again in 1946 with this second volume, in which there is an examination of the part being played by private investment in the post-war world, despite the vast increase in the international flow of public capital.

Exchange control and the general preoccupation with balance of payments problems have led to a marked increase and improvement in the evidence available since 1939 upon this question. It is true that certain kinds of capital flow escape being recorded, chief amongst these being the clandestine export of capital and the reinvestment of profits. It is also the case that capital holdings are often now blocked (cf. the sterling balances) so that the movements shown do not tell the whole story. Yet in other respects the coverage has become much more complete, especially in relation to the Investment and Financing Account of the capital exporting countries. In addition supplementary information is now obtained in some countries by direct enquiries such as the U.S. Census of Direct Private Foreign Investments and by other independent methods such as the Bank of England estimates of outstanding overseas business investments. Whereas the analysis for the inter-war years was based largely upon estimates of aggregate net inflow or outflow, divided as

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far as possible into short-term and long-term movements with a large residual, the data for post-war years are much more firmly based and contain much greater detail.

This report is a most valuable source book of information upon the regional distribution and industrial character of international capital movements. Although the statistical material for the different countries is even now not of equal validity, and international comparisons must to some extent still be qualified, the broad picture is clear enough. The international flow of private capital has increased steadily since the war and may have exceeded $2000 million in the last few years, a level previously equalled only in the peak capital exporting years of the 1920's. Allowing for the post-war rise in world prices of goods, however, the post-war flow is well below that of the 1920's while it is very small indeed in relation to the rates of investment required in the underdeveloped countries if their development is to be promoted at any appreciable rate.

In the post-war world the United States is overwhelmingly the main source of private capital, with the United Kingdom second and Switzerland third. The figures for France, relating as they do to the franc union, are misleading since they do not show transfers between metropolitan France and her overseas territories. In the capital importing countries the ordering is again quite unambiguous. Canada is the biggest single recipient of private capital from the United States with the United Kingdom and continental Western Europe together being second and Venezuela third.

This kind of comparison depends to some extent upon the size of the geographical unit taken. It must also be qualified by analysis by industry. From the industry analysis it emerges that the overwhelming bulk of U.S. direct private foreign investment goes into petroleum extraction, refining and distribution. Manufacturing also absorbs a large part of U.S. private investment abroad, but Canada proves to be the most important field for U.S. investment of this type, with Latin America and Western Europe next. If we exclude petroleum, it is clear that U.S. private direct investment is attracted preponderantly to highly industrialized and rich countries and not to those whose populations are most numerous and whose need for capital is greatest.

Yet it is agreed policy both in Point Four and in the development plans of the Colonial Powers that the task of promoting productive investment must largely fall to private capital. The public loans and grants which are flowing to the underdeveloped areas are planned to finance the development of public utilities and social overheads, such as the extension of systems of transport and communications. The General Assembly of the U.N. has often referred to the importance of stimulating the international flow of private capital to supplement this public capital for the economic development of underdeveloped countries. The statistics presented in these reports demonstrate the inadequacy of this flow of private capital.

The report also offers a brief analysis of the obstacles to private capital inflow in underdeveloped countries. It seems that this phenomenon is not new. Rich countries have for the last thirty years appeared to offer better markets to potential investors in secondary industries and private capital has almost always gone to underdeveloped areas only in search of raw materials. American private capital, now the most important source of funds, appears to be following the same paths as did the private investors of imperial France and Britain. This is only one of the many interesting implications of this study.

The task of financing the rapid economic development of underdeveloped areas presents many problems and it is with some of these that this report deals. Both the statistical and the general economic analysis are of a high order, making this report, with its earlier companion volume, important works of reference in this field.

P. ADY.

16.—*The Measurement of Consumers' Expenditure and Behaviour in the United Kingdom*, 1920–1938. Vol. 1. By Richard Stone, assisted by D. A. Rowe and by W. J. Corlett, Renée Hurstfield, Muriel Potter. 1954. 448 pp. £5 5*s.* net.

Consumers' Expenditure in the United Kingdom, 1900–1919. By A. R. Prest, assisted by A. A. Adams. 1954. 196 pp. 42*s.* net. Cambridge University Press.

These volumes are two of those sponsored by the National Institute of Economic and Social Research of the Cambridge University Department of Applied Economics under the general heading Studies in the National Income and Expenditure of the United Kingdom. Number 5 of the series, the first to be issued, *Wages and Salaries in the United Kingdom, 1920 to 1938*, was reviewed in the *Journal*, 1953, pp. 210–3. Of these studies of Consumers' Expenditure, that for 1900–1919 was published in May, 1954, while for the latter period, 1920–1938, the treatment is divided into two volumes, of which the first only is yet available (dated January, 1953).

The whole series is remarkable for the colossal amount of research into all possible sources, hundreds of which are listed, the close analysis of their content, and critical judgment of reliability. Very great detail is published, and it is perhaps safe to say that there is nothing more to be known about the *aggregate* private expenditure in the United Kingdom on most consumers' *goods*. The

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treatment is necessarily less complete on services, and though there is some analysis from budgets of the expenditure of different income groups, there is none of an individual's preference.

A disadvantage of the publication of so much detail is the expense and bulkiness of the volumes. The pages are 12 in. by 10 in. without break into columns, and Mr. Stone's, of 448 pages, weighs over 5 lb.

Before using any of the statistics, a reader should study very closely the preliminary definitions and discussions of consumers' expenditure. For example, what relation there is between wholesale and retail costs, whether the totals relate only to private individuals, or include institutions, government or army, what allowance is to be made, on the one hand, for home production and consumption and, on the other, for expenses necessary for earning or for business entertainment. Again there are many instances where reports are only available occasionally and interpolation is necessary, wherein the relationship between quantity and price is uncertain.

The expenditures, quantities and prices are given yearly separately for very many items.* These are then combined under general headings, for example, eleven for Food, and combined again for Food as a Whole (Stone, p. 174),† and in 1900–19 for Total Expenditure (Prest, p. 175)† on the same general classification as in the post-war White Paper, *National Income and Expenditure*, Cmd. 7933.

Apart from the difficulty of the definition of Consumers' Expenditure as a whole, there is also an arbitrariness in classification under sub-headings. Thus Prest (pp. 183–5) continues his estimates to 1920 to compare with Stone's for the same year. Southern Ireland ceased to be statistically part of the United Kingdom in 1922. Prest includes and Stone excludes Southern Ireland throughout. In 1920 this difference amounts to about 4 per cent. of the total. The first line on p. 184 (Prest) gives a striking example. *Flour*, 1920, *U.K.* Stone £m *231*, Prest £m 190, less S.I. £m 12 = £m *178*. The difference is due to Stone's inclusion of the full value of "cakes, etc.", while Prest includes only flour and part of the cost of manufacture. The totals for food are, however, reconciled. It is thus hazardous to combine the various series for 1900–19 and 1920–38 into one continuous account.

Statisticians will naturally wish to link pre-war estimates with those contained in the official White Papers for 1938 and subsequent years. Unfortunately, while the totals for food are very nearly the same, the classification for groups of food differs very widely. In the adjoining Table the verbal classification is that in the White Paper *National Income and Expenditure of the United*

Consumers' Expenditure on Food, 1938

£ *millions*

	Cmd. 7933		Stone, p. 171
	Table 21	*Adjusted*	
Bread and cereals	162	177	186
Meat and bacon	327	—	—
Meat, poultry and eggs	—	410	438
Fish	54	60	38
Oils and fats	78	—	—
Margarine and other fats	—	19	23
Sugar, preserves and confectionery	107	—	—
Sugar, chocolate and confectionery	—	85	83
Dairy products	179	228	212
Fruit	85	—	—
Fruit and nuts	—	94	79
Potatoes and vegetables	99	—	—
Vegetables	—	104	94
Beverages	62	—	—
Tea, coffee and cocoa	—	59	57
Other manufactured food	36	—	—
Other foods	—	105	71
Total household expenditure	1189	—	—
Other personal expenditure	116	—	—
Total	1305	1341	1301

* From the equation $E = QP$, in some cases Q (quantity), in others P (price) is deduced from estimates of the other terms (see Prest pp. 280–1). It is not clear how P or Q are found in the case of services, where only E (expenditure) has been estimated.

† References to the two volumes are given as *Prest* for 1900–19 and *Stone* for 1920–38.

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Kingdom, 1946 to 1949, Table 21. The Ministry of Food communicated details which enabled Mr. Stone to recast these figures in accordance with the classification he used. This classification is inset and the second and third numerical columns in the Table show the result. The discrepancies in detail are still serious, but a considerable difference is due to the Ministry's separation of household expenditure from expenditure at restaurants, etc. and food produced and consumed on farms. The result is that we can link together with due caution the estimates of the totals of the value of food consumed from 1900 to 1953, but for sub-classification we are dealing with three different definitions.

The 1920–1938 volume contains Part I, *Estimates of Consumers' Expenditure*, and Part II, The *Analysis of Market Demand* preceded by an Introduction termed *Econometric Economic Analysis and Policy*. Part I covers the same 16 sections as in Prest, pp. 1–116, but not the remaining sections, which refer mainly to services and miscellaneous expenditures; these accounted for about half of the total consumers' expenditure in 1919.

In Part II we find a long and elaborate mathematical discussion of the formulation of equations of demand over time, with application to the series of expenditure on the various kinds of food, as detailed in Part I. To obtain income as well as price elasticities a new analysis of the 1937–8 working class budgets* has been made, and the results incorporated in the time series. The resulting Tables can only be understood after a close study of the analysis and symbols used. Thirty-seven full page diagrams, which illustrate the details of the equations relating to various kinds of food, and further diagrams relating to Drink, Tobacco, Fuel and Light are difficult to use for want of appropriate headings and explanation of the vertical and horizontal scales. It is not possible to give any quotation of the results of Part II that would be explicit without long explanations.

How far this analysis of consumers' behaviour is applicable to post-war conditions for forecasting and policy is doubtful. "Before the equations based on pre-war experience can be used as a guide to post-war possibilities some correction is needed at least where it is to be expected that the greater equality of incomes will appreciably affect demand" (Stone, p. 253). But this intensive search of available data and the methods of calculating relevant formulae should be of permanent utility.

Among the many bye-products of the investigation attention may be drawn to Tables 61–64 (pp. 172–3 Stone) entitled "*Nutrients available for Consumption per head per day in the United Kingdom, 1920–38*", in which estimates are given for each year of Protein, Calories and various Vitamins and Calcium and Iron. Since these are simply totals, there is no guide as to the adequacy of the consumption in separate families, nor can the computation of the number of "equivalent adults" (pp. 416–7) and its use in these Tables be accepted without reservation.

A. L. BOWLEY.

17.—*An Introduction to the Study of Industrial Relations.* By J. Henry Richardson, M.A., Ph.D. London: George Allen and Unwin, 1954. 442 pp. 8¼″. 30*s.* net.

Since about 1910 there have been vast changes in social organization, though it is only in retrospect that their dramatic and revolutionary character can be fully appreciated. These changes, so profound in their reactions on the structure of society and the distribution of the national wealth, have come about by an almost imperceptible evolutionary process. This has given time for the adaptations necessary if the changes were to take place without the social waste attendant upon "revolution" in the modern industrial state. One of the most striking developments of the past half-century has been the transformation of industrial relations which has been associated not only with the rise of the trade unions but also with a wider recognition of the producer as a human being entitled to be consulted and heard. Professor Richardson has filled a gap in the study of social evolution by this thorough survey of the field of industrial relations. In doing so, he hopes, modestly, that his book "will prove useful to university students and others interested in human aspects of industrial management and in the regulation of working conditions by collective agreements between employers and trade unions or by statutory methods". Professor Richardson's qualifications for the exacting task he set himself are unexceptionable. He served for nine years as a member of the permanent diplomatic staff of the International Labour Office in Geneva; he has been Montague Burton Professor of Industrial Relations in the University of Leeds since 1930; he has served as a member of Trade Boards; and he has advised the Government on labour policy and the regulation of working conditions.

Much of the book is of necessity descriptive. The material has been arranged under five main headings: Relations at the Workplace; Collective Relations; Wages and Hours of Work; State Intervention; and International Aspects. With the aid of a very full index, an example incidentally

* P. Massey's "British Middle-class Households, 1938–39" (*J.R. Statist. Soc.*, 1942, pp. 159–96) is also used.

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that should be more widely followed, there are few aspects of "industrial relations" in the widest sense upon which the enquirer will not readily find the information he wants, whether it concerns methods of wage payment, job evaluation or joint consultation; collective bargaining, the position of civil servants, recognition of trade unions, or the closed shop; wage bases, equal pay for equal work, or hours of work; a national wages policy, conciliation or social security; and, for full measure, international aspects, including the International Labour Office. In short, the work is a cyclopaedia of the subject. One can judge its merits, therefore, only by taking a few random samples out of a multifarious array of subjects with which the reviewer may be familiar.

Take, as an example, the problem of the closed shop. The various meanings of the term and the development of the idea both here and in the United States are well described. It is only since 1932 that the "yellow dog" contract, in which the worker as a condition of employment undertook not to join a trade union, has been illegal in the United States. Professor Richardson gives us a clear account of the acceptance by the London Passenger Transport Board of the closed shop principle by not continuing in its service any employees in grades covered by its agreement with the Transport and General Workers Union who were not members of that union. He remarks: "The Board evidently believed that only by ending the friction resulting from rival unions by deciding in favour of the long-recognized and much more representative union could it properly perform its duties to the public of providing an efficient transport service".

Under the general heading of Wage Bases and Principles, Professor Richardson gives a dispassionate account of the main considerations raised in wage negotiations, which he groups under the headings of the capacity of industry to pay, workers' standards of living, and internal and external relationships between the wages of the workers concerned and those paid to other workers. He remarks that "the days are gone by when big strikes had a chance of securing gains for the workpeople which would compensate them for the losses of the stoppage and leave them better off in future . . . . Profits are so severely taxed to provide the foundations of the Welfare State that the residue yields only a moderate return on capital in most industries". He goes on: "Substantial increases in real wages can . . . be gained not by conflicts over division of the product of industry but by co-operation to increase the amount produced". The discussion of the concept of a "living wage" and of the use of cost of living and selling price sliding scales will be useful to many students of industrial affairs.

In a chapter on Equal Pay for Equal Work, the view is expressed that: "Not only in the professions, but in industry, the Civil Service, and other occupations, application of the principle of equal pay for equal work to men and women alike is economically sound and an expression of elementary social justice". On the question of relative efficiency the author remarks that demand and supply would determine the proportions of men and women to be employed in different occupations.

In view of the recent publication of the Report of the Phillips Committee on the Economic and Financial Problems of Provision for Old Age, it is interesting to note Professor Richardson's observations on the retiring age, written of course long before that Committee reported. He says that earlier retirement, though advocated as a remedy for unemployment, has often been regarded as a desirable permanent change. It may indeed be recollected that State Pensions at 60, conditional upon retirement from work, were mooted during the 1921–31 economic crisis. It may be observed that some trade unions still make their officials retire as early as 60 or even 55. The movement before the War towards earlier retirement assumed of course that people would prefer to retire at say 60 rather than 65 or 70, but this is certainly not valid for large numbers of people so long as they remain fit. After reviewing such factors as the growing proportion of old to young people; improvements in health standards, and the rise in the expectation of life; the effects of better education; and the reduction of heavy manual toil by use of machines, Professor Richardson thinks it would be sound policy to raise and not to lower the age at which people are required to cease work. It will be observed that this conclusion is based on broad social grounds, quite apart from the growing burden of pensions on the economy which led the Phillips Committee to recommend *inter alia* the raising by stages of the minimum age of retirement for national pensions from 65 to 68 for men (60 to 63 for women).

Space permits a reference to only one further subject, namely, "Joint Consultation", an all-embracing term which seems to cover everything from informal talks with individual workers; arrangements by which representatives of the workers, sometimes shop stewards, can put their point of view to the management from time to time; to regular formal meetings of works councils and joint production committees. The practical impossibility in large undertakings of maintaining adequate direct personal contact between the higher management and the main body of the workpeople has created the need for organized channels of communication. The nationalized industries are required by statute to adopt systems of joint consultation, at the workplace as well as regionally and nationally, though, the author thinks, joint consultation by legislation is of doubtful value in private industry: "Legal authority cannot create in management and workpeople that genuine desire for joint consultation which is necessary for success". The whole purpose of joint consulta-

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tion is that changes in policy, including machinery, organization, processes and products, should not be announced as decisions already taken but submitted as projects which can be adjusted in the light of suggestions made by representatives of the workpeople. The late Sir Stafford Cripps's insistence upon the need for such consultation in order to stimulate production in munition factories in the War will be recalled. The relationship to the unions of the staff representatives on joint bodies concerned with production is a difficult one. Men most active in trade union work are not necessarily the most effective on the work of joint consultation, especially on questions of production and discipline. Moreover, Professor Richardson points out, trade union methods and leadership have been based largely on a "two sides" attitude of conflict, whereas the success of works councils and joint production committees depends on recognition of common interests. The job of representatives "is mainly constructive co-operation and not class conflict". The author mentions that trade unions train shop stewards and others in time and movement studies, job evaluation, and other subjects which are discussed at joint production committees and works councils. "In industry as in politics and in trade unionism", he says, "the apathy of the rank and file is notorious". Much remains to be done, especially in large undertakings, if joint consultation is to be an effective influence on production from which all benefit.

This dispassionate study of a vital subject will be a constant work of reference for all those whose responsibility it is to develop and maintain co-operative relations between management and workers. The book is indeed a striking reminder of the radical changes in managerial outlook towards the rank and file of industry which have occurred since World War I.

F. A. A. MENZLER.

18.—*Wartime Agriculture in Australia and New Zealand*, 1939–50. By J. G. Crawford and others. Stanford, California: Stanford University Press, 1954. xiii + 354 pp. 9″. $7.50.

This book is one of a series of studies on wartime management of food and agriculture undertaken by the Stanford Institute, aided by a grant from the Rockefeller Foundation. The greater part of the book deals with Australia and has been written by a team of four authors headed by J. G. Crawford, Secretary of the Department of Commerce and Agriculture at Canberra. The New Zealand section of the book is contributed by A. A. Ross of the New Zealand Department of Agriculture. The wartime agricultural problems of Australia and New Zealand were mainly those of fitting production to meet the changing demands of the United Kingdom and, at a later stage, of the United States forces in the Pacific. Notwithstanding the acute shortage of manpower, fertilizers and mechanized equipment, the study shows how the Australian and New Zealand farmers were able to make a sustained effort to meet vital wartime needs. By 1943, when agricultural policy and administration had become more effective, greater co-ordination resulted in a maximum contribution to the war effort. Chapters are devoted to the production of crops and livestock and livestock by-products, to manpower, and to price policy and the acceptance of cost of production as the basis of price fixing. Post-war trends are discussed in the concluding chapters of each of the two sections of the Survey. The text is well supported by statistical tables and charts, derived from official data. Sources are enlisted in a bibliography and helpful indexes are provided. This clearly-written short history of agricultural developments in Australia and New Zealand during the second World War is an invaluable reminder of the help these major producing countries were able to provide. In the present world situation the study should also attract wide interest for its outline of the investment, importation and other priority needs Australia and New Zealand, as large food producers and exporters, will have to consider in the next decade.

J. H. GORVIN.

19.—*Retail Trading in Britain* 1850–1950. By James B. Jefferys. Cambridge University Press, 1954. xvii + 497 pp. 12 plates. 9″. 50*s*.

This, the thirteenth of the economic and social studies of the National Institute of Economic and Social Research, is the story of the rise of the large scale retailer rather than a complete history of retailing in Great Britain over the past 100 years. The retail trade in the second half of the 19th century and the small independent retailer are only discussed in sufficient detail to provide a background to this story.

The rise of large scale organizations in the retail trade was made possible by the development of a mass market and new products that followed in the train of the Industrial Revolution. Owing to the advantages of large scale buying, its increased capital resources and its ability to employ specialist experts, a large organization has an advantage in efficiency which enabled it to compete successfully with the independent trader as soon as the development of a large working class demand for consumer goods and easier transport made its existence possible.

There were two routes to increased size, either an expansion in the number of outlets giving rise to the multiple chains, or an increase in the range of goods sold to expand a single shop and give

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the departmental store. A third type, the Co-operative Societies, grew out of a combination of a reputation for honest trading and many, but not all, of the advantages of the large scale retailer. In the inter-war years the growth of these three types of organization was only limited by the availability of main street shopping sites and the effect of branding and packaging by the producer himself, usually accompanied by resale price maintenance, in enabling the small shop conveniently sited to serve a local clientele, to hold its own against the lower cost trading methods of the multiple.

The book consists of an analysis of the effect of these and other factors on the growth of the three types of large organization in each of several different trades. The opening chapters provide a general picture followed by a chapter on each of fifteen different trades. These are sub-divided into separate sections in which the progress of each type of trader is followed through different periods of time. This method of treatment involves a large amount of repetition and the reader is left feeling that the book could have been considerably reduced in size with no loss of subject matter, but a gain in the vividness and clarity of the picture painted.

One great difficulty experienced by a writer dealing with the distributive trades is the dearth of statistics on all but the Co-operative Societies. Mr. Jefferys has done a great deal to remedy this by his own researches, and the backbone of the present volume is formed by the results of a statistical inquiry into the growth of large retailers over the past fifty years. This comprised a search through directories, together with the questioning of some 800 firms and organizations as to their past progress measured in terms of number of branches and turnover.

The results are presented in the form of tables showing the progress of each of the three types of large scale trading organization in the fifteen trades as measured by the number of outlets. These figures are given in considerable detail, showing the rates of expansion year by year and the proportions owned by firms in different size groups. Some attempt has also been made to estimate turnover figures and these are presented in the form of tables showing the percentage share of the market held by each type of organization. The share held by independent traders is in each case calculated as a residue. It is, however, the tables showing the number of outlets that are made the main basis of the argument. There are very large variations in size between the branches even of a single multiple firm and, as the author himself admits, the number of outlets is a very unsatisfactory measure of size, and it is unfortunate that it had to be used in this way to such a large extent. The tables of total turnover, although only very broad estimates, could have been usefully combined with those for the number of outlets to show changes with time in the average size of individual shops and differences between various types of trader.

Although limits are given for the accuracy of the turnover tables no indication is given as to how these limits have been arrived at. The explanations given in the appendix of the methods used in calculating the estimates and the very arbitrary corrections made to make them agree with the 1950 Census of Distribution figures are hardly such as to increase the reader's confidence in them. Even the one figure one might expect to be correct, that for the number of multiple branches in 1950, differed by as much as 12½ per cent. from the Census figure. In view of the reticence of most traders with regard to their turnover figures it would be useful to know more about the proportionate response to Mr. Jeffrys' enquiries from individual firms.

One subject of great interest that runs throughout the author's analysis is the growth of resale price maintenance and the way in which it in turn has influenced the development of the large retailer. The effects of both price fixing and cut price warfare are traced, but apart from the undoubted effect of resale price maintenance in maintaining the position of the small independent retailer, it is, perhaps not unnaturally, impossible to make any definite conclusions either for or against its desirability. Certainly its absence in the clothing trade has enabled the variety chains to pass on the economies of their method of trading to the customer in the form of lower prices with a very considerable degree of success, and the descriptions of price wars do not suggest that they have had a disastrous effect either on the producer or the distributor. Yet, on the other hand, in the grocery and provisions trade, where a high proportion of the goods sold are price maintained, there is no evidence of a lack of initiative in the development of new trading methods. The large self-service store of the type being opened to-day, selling cellophane-packed provisions from refrigerated cabinets, represents a greater advance on the multiple shop of fifteen years ago than the latter did on the grocer of fifty years earlier.

These developments, which were little more than plans in 1950, are foreshadowed in the chapters on future trends, and the effect of resale price maintenance on them is a point of considerable interest which is discussed at some length.

B. T. RAMM.

Editors' note on a previous review:

With reference to the review of Professor Brinley Thomas's *Migration and Economic Growth* (Cambridge University Press, 1954), which appeared in the *Journal*, Series A General, Volume

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117, Part 4, 1954, Professor Brinley Thomas writes: "There is a serious mis-statement in the review to which I must draw attention. Referring to my time-lag analysis, the reviewer writes: 'It is significant that only the U.S. statistics of British immigration are used in this analysis; the use of the U.K. series might give very different results' (p. 491). This statement is not true. In addition to the U.S. statistics of British immigration to the United States, I used the U.K. Statistics of British persons sailing from the United Kingdom to the United States. This is clearly shown in Table 49 (p. 161 of the book), and in Appendix 2 (pp. 261–2 of the book), and the British series used is printed in Table 106 (p. 296 of the book).

"Having given an inaccurate description of the book's lag analysis, the reviewer went on to infer that 'time lag analysis might give different results according to the series used' (p. 492). So far as the time-lag analysis in my book is concerned, the reviewer's inference is not justified: both the British and the American statistics of the migration of British persons to the United States in the period 1853–1913 gave similar results (see p. 161 and pp. 261–2 of the book)."

We are asked by the reviewer to state that he greatly regrets this error owing to lack of care in reading the text which comments on the tables in question.

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STATISTICAL NOTES

(1) British Official Statistics

The interim index of reatil prices published by the Ministry of Labour and National Service, which was 145 (prices at June 17th, 1947 = 100) in July, fell to 144 in August and to 143 in September. In October it was 144 and in November and December 145. The decline in August and September was mainly due to reductions in the price of certain vegetables and of butter. These reductions were partly offset by increases in the prices of milk, eggs and meat. The higher level of the index in the next three months was due to increased prices for eggs, tea, fish, potatoes, meat and, in some areas, coal. Separate figures on the same basis (i.e. June, 1947 = 100) are not available for the different groups of commodities, but the following are the figures based on January 15th, 1952 = 100.

Date	*Food*	*Rent and Rates*	*Clothing*	*Fuel and Light*	*Household Durable Goods*	*Miscellaneous Goods*	*Services*	*Alcoholic Drinks*	*Tobacco*	*All Items*
Weights:	399	72	98	66	62	44	91	78	90	1,000
July 13th, 1954	118·0	112·0	96·3	110·2	95·1	100·1	110·2	101·6	100·3	109·1
August 17th, 1954	116·2	112·2	96·3	110·2	95·1	100·1	110·3	101·6	100·3	108·4
Sept. 14th, 1954	115·2	112·3	96·3	110·7	95·1	100·1	111·3	101·6	100·3	108·2
Oct. 12th, 1954	116·1	112·3	96·3	111·0	95·1	100·2	112·2	101·6	100·3	108·7
Nov. 16th, 1954	116·9	112·7	96·4	113·7	95·1	100·3	112·4	101·6	100·3	109·2
Dec. 14th, 1954	118·2	113·2	95·8	114·5	95·1	99·5	112·5	102·6	100·3	109·8

The Ministry of Labour index of weekly wage rates, which was 142 in July (June 30th, 1947 = 100), rose to 143 in August, September and October and to 144 in November and December. The principal classes of workers whose rates of wages were increased during the period included iron and steel workers, those engaged in hosiery and carpet manufacture, tobacco workers, railway employees, cotton operatives, milk distributive workers, bakers, men and women in retail grocery and local authority employees.

The six-monthly inquiry into average earnings showed that in April, 1954, the average earnings per week in the industries covered by the inquiries were 197*s.* 8*d.* for men, 105*s.* 3*d.* for women, 82*s.* for boys and youths and 65*s.* 10*d.* for girls. These figures represent increases over October, 1938, of 187, 224, 214 and 256 per cent. For all workers combined the average was 166*s.* 6*d.*, an increase of 213 per cent. The index for April, 1954, compared with 100 at April, 1947, was 161. This compares with the wage *rate* index of 141. The average hours worked in April, 1954, were 46·1 per week (48·2 for men only). In manufacturing industries alone the average earnings in April, 1954, were 205*s.* 2*d.* for men and 105*s.* 10*d.* for women. The same enquiry showed that in establishments employing 5½ million workers 663,500 employees were on shift work. Of these, 46 per cent. were on a three-shift system, 24 per cent. on alternating day and night shifts and 16 per cent. on double day shifts.

The total working population and the numbers in civil employment in the six months ended November, 1954, were as follows:

(*Thousands*)

	Total Working Population			*Numbers in Civil Employment*		
	Males	*Females*	*Total*	*Males*	*Females*	*Total*
June, 1954	15,918	7,610	23,528	14,953	7,512	22,465
July, 1954	15,934	7,644	23,578	14,971	7,547	22,518
Aug., 1954	15,985	7,699	23,684	15,016	7,597	22,613
Sept., 1954	15,984	7,713	23,697	15,011	7,603	22,614
Oct., 1954	15,990	7,733	23,723	15,014	7,621	22,635
Nov., 1954	16,004	7,771	23,775	15,025	7,660	22,685

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The number of persons on the unemployment registers of the Employment Exchanges rose by 36,000 between July and December. The total of 256,308 at December, 1954, represented 1·2 per cent. of the estimated total of employees in Great Britain. The percentage in the different Regions ranged from 0·5 in the Midlands and North Midlands to 2·0 in Northern Counties, 2·2 in Wales and 2·7 in Scotland.

The following is a sex analysis of the figures:

Number of Unemployed Persons on the Registers of Employment Exchanges

Date	*Men and Boys*	*Women and Girls*	*Total*
July 12th, 1954 . . .	143,586	76,547	220,133
Aug. 9th, 1954 . . .	156,610	82,999	239,609
Sept. 13th, 1954 . . .	149,069	86,958	236,027
Oct. 11th, 1954 . . .	159,599	94,315	253,914
Nov. 15th, 1954 . . .	165,874	97,185	263,059
Dec. 6th, 1954 . . .	163,351	92,957	256,308

Of the total of 256,308 at December 6th, 71,179 had been unemployed for not more than two weeks, 70,992 for two to eight weeks and 103,143 for more than eight weeks, while 10,994 were temporarily stopped.

The numbers of insured persons absent from work owing to sickness, including self-employed as well as employed, were 817,600 in July, 804,800 in August, 841,100 in September, 898,100 in October, 913,000 in November and 918,700 in December. The numbers of employed persons absent owing to industrial injuries were 54,900, 52,400, 57,100, 59,700, 59,600 and 55,100.

The aggregate membership of trade unions in the United Kingdom as shown in the *Ministry of Labour Gazette* for November was 9,461,000 at the end of 1953. This was about 60,000 less than at the end of 1952 and 3,163,000 more than in 1939. Of the total membership, 67 per cent. were in 17 unions with a membership of 100,000 or more and 12 per cent. were in 16 unions with a membership of 50,000 to 100,000. General labour organizations accounted for 2,100,230 members, 1,773,720 were in metal trade unions and 833,020 in coal mining unions.

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(2) Other Statistics

The Research Committee of the Society of Incorporated Accountants and Auditors has recently published a *Register of International Research in Accounting* (Oxford University Press, 1954: 7*s.* 6*d.* net). According to Professor F. Sewell Bray's Foreword, the "intention of this register is to familiarize new research workers with what is already going on, and to help those already committed to keep in touch with changing ideas. It is also hoped that it will have its uses for those who work in other related fields of inquiry". It is appropriate that the preparation of this useful and informative Register should have been undertaken under the auspices of the "Society" which, in 1952, took the important step of creating the Stamp-Martin Chair of Accounting, to which Mr. Sewell Bray was appointed as first Professor. The Register is evidence, if any were needed, that accountants the world over have ceased to be content to be recorders of financial facts. The list of accounting bodies, universities and institutions sponsoring research and the wide range of subjects covered are impressive.

C.I.B. Bulletins 1954, *Nos.* 2 *and* 3. (International Council for Building Research Studies and Documentation): The object of this series is to promote building productivity by facilitating international co-operation in research and documentation. To this end, periodic loose-leaf, illustrated bulletins are issued in three languages. Subjects dealt with in these two issues range from the restoration of Versailles to comparative costs of steel and reinforced concrete in aircraft hanger construction, and include résumés of work in national building and civil engineering laboratories, as well as lists of relevant publications. While these two bulletins contain little specifically statistical material statisticians concerned with any aspect of building may care to have their attention drawn to this new source of information.

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Readership Surveys—No. 1. (Market Research Society, 1954. 2*s.* 6*d.*). A committee of the Market Research Society (whose President is Sir Arthur Bowley) prepared this booklet mainly for buyers of advertising space but also for others interested in investigations into "readership" defined as the number of persons who have had a chance of seeing an advertisement in a given publication. Sampling techniques already used are described, with suggestions for improvement. Planners of all types of sample surveys may find something of value in this critical account of methods.

The Bureau of Social and Economic Research of the Canadian Jewish Congress has undertaken the preparation of a series of studies on the structure and growth of the Jewish community in Canada during the first half of the twentieth century. Comprehensive demographic studies of special communities are always of interest from a methodological point of view apart from their particular application to the problems to which they are directed. These studies will cover sex and age distribution, immigration, mother tongue, intermarriage and occupational distribution. The first study deals with changes in the geographic distribution of the Jewish population in the Metropolitan area of Toronto. The studies may be obtained from the National Headquarters of the Canadian Jewish Congress, 493, Sherbrooke St. West, Montreal.

With the publication of *Federal Statistics, The Activities of the Federal Statistical Office and the Statistics processed by the Supreme Federal Authorities position on* 31*st December* 1953 (Statistics of the Federal Republic of Germany, Vol. 82), the Federal Statistical Office resumes the practice of the former Reich Statistical Office, which, until 1941, issued similar publications every second year in the series "Statistik des Deutschen Reiches". Part A of the present volume is a general description of organization and method in the field of Federal Statistics. Part B consists of catologues of official statistics, and Part C lists alphabetically references to these catologues.

Since it is stated early in Part A that the organization and working methods of German statistics cannot be understood without the information given in the outlines which comprise the remainder of that Part, statisticians who make use of the Federal Statistics for the first time, or only occasionally, will probably be glad of the help there provided.

CURRENT NOTES

The International Journal of Abstracts on Statistical Methods in Industry has appointed Dr. E. H. Lloyd, of the Mathematics Department, Imperial College, London, S.W.7, as Regional Editor for the United Kingdom. Dr. Lloyd would be glad to supply information on the new Journal and to receive offers of help in locating and abstracting papers and articles of statistical interest, particularly those which get published in scientific and technological journals not devoted mainly to statistics.

The Fellows named below were included in the New Year's Honours List, 1955:

C.B.E. Miss J. M. MATON.
O.B.E. G. M. MORANT.
M.B.E. J. H. WEST.

Fellows will wish to congratulate Professor G. A. Barnard on his recent appointment to the University Chair of Statistics tenable at the Imperial College of Science and Technology.

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OBITUARY

Dr. L. Rostas

Dr. L. Rostas was born in 1909 at Budapest, and was educated at Budapest University as a pupil of the late Professor Navratil. He graduated in law and economics, and soon achieved distinction by winning first prize in an award offered by the Hungarian Academy of Sciences for an original work on the causes of industrial fluctuations. Fortunately for England he was invited, shortly before the war, to come to this country and do research work under the auspices of the National Institute of Economic and Social Research, and he arrived in 1939. Nationality considerations made it impossible for him to work in a Government Department, but his presence strengthened the small band of economic statisticians who were still free to do independent work during the war.

His first task in England was to collaborate with Professor and Mrs. Hicks in investigating problems connected with war taxation, and he was joint author with them of *The Taxation of War Wealth*, published in 1941; the National Institute made a grant which covered Rostas' salary for this work, but was not otherwise responsible for it. On the other hand it was essentially responsible for the further work which he proceeded to do on taxation matters, and which occupied the next 1½ years or so: this was done in collaboration with Professor Shirras and resulted in a valuable and comprehensive survey of the incidence of British taxes, published in 1942 as *The Burden of British Taxation*, by Shirras and Rostas.

The National Institute then entrusted to him an empirical enquiry into the relationship of prices to various cost items and to gross profit margins, which involved considerable use of the censuses of production. It was in the course of doing this work that he realized that the data which he was handling could be used to make a number of very interesting international comparisons. The result was his famous article in the Economic Journal for April, 1943, entitled *Industrial Production, Productivity and Distribution in Britain, Germany and the United States*, 1935–37.

This title, long as it may seem, barely indicates all the topics covered in that sixteen-page article. The part which has become so famous occupies, indeed, under four pages, of which one consists of tables. Perhaps Dr. Rostas did not realize what a tremendous influence those four pages were to have, not only on his own reputation and on the whole subject of international comparisons of output per head, but on the practical action taken in sending "Productivity Missions" to the United States. If he had, he might have confined his article to that part of the subject and treated it at greater length; yet this would have meant the loss of much other material of great interest which is in the article.

The fuller treatment of international productivity comparisons was to come later, in his book *Comparative Productivity in British and American Industry*, substantially completed in 1946 but not finally published until 1948. Here the most captious critic could hardly complain of inadequate documentation and explanations, as the calculations for each industry were reproduced almost in full. More industries had been added, data from other sources besides the census incorporated, the main limitations and difficulties discussed in each case; the general methodology and philosophy of the comparisons were also examined at some length, and an attempt made to extend the comparison (albeit on a less elaborate basis) to other sectors of the economy besides manufactures, and to reconcile the great advantage of the U.S. in output per head in manufactures with her much smaller advantages in average real income. Particularly in these last respects the book added a great deal to the value and interest of the results, and the whole work is given much more unity and "shape". Logically, therefore, it is this book which one ought to associate with the name of Rostas, as really reflecting his contribution to the subject; but the revised figures, though for some industries materially different from those originally given, did not create any new impression of the over-all comparison, and the four pages of the 1943 article will somehow remain as his chief memorial.

The validity of their picture had by no means been universally accepted, even in the broad. Constructive criticism was always welcomed by Rostas, and much of what he received is incorporated in the more solid basis of the calculations used for his book. He had always recognized, and indeed emphasized, the difficulties of making an exact comparison for any industry, and in particular the inevitable uncertainty caused by possible differences in quality. He did not, however, accept the extreme thesis put forward by Dr. Snow in his Presidential Address to the R.S.S. in March 1944, that the two censuses "do not afford a reliable means for comparing industrial productivity per head". In part, of course, this was a question of the meaning of "reliable", and of how much margin of possible error one should tolerate before declaring a set of figures useless. Dr. Rostas

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showed, in his reply to Dr. Snow, that the possible error due to some of the alleged non-comparabilities was very small, but no objective limit could be set to others (such as possible differences in average quality). The discussion, however, helped to underline the importance of the subject, and to draw attention to it.

Some results of the main inquiry on which Rostas had been at work, and from which the work on international comparisons was really a digression, appeared in 1948 as *Productivity, Prices and Distribution in Selected British Industries*. Meanwhile he had left the National Institute in December, 1946, for the Statistics Division of the Board of Trade, where he became the specialist on all problems connected with productivity comparisons through time or between this country and others. He was the British representative on the O.E.E.C. sub-committee studying productivity at Paris, where he played a leading role in the work. When he resigned from the Board of Trade to take an assistant directorship of research at Cambridge, in 1951, he continued these activities (and others in London) as a part-time adviser on productivity—an appointment which showed the high value set on his work by the Board of Trade.

Rostas' untimely death has deprived economic statistics of an able and original practitioner and many people of a trusted colleague and generous-hearted friend.

W. B. REDDAWAY.

B. SEEBOHM ROWNTREE, C.H.

1871–1954

THE death of Seebohm Rowntree in October, 1954, will be regretted by the large number of his friends and those with whom he worked, and by those Fellows of the Royal Statistical Society* who have profited by his achievements and example in realistic statistical investigation.

Rowntree first became well known in his book *Poverty: A Study of Town Life*, 1901. Already interested in social questions, following the traditions of his family and of the Society of Friends of which they were active members, and with intimate knowledge of the population of York, he was inspired by Charles Booth's *Life and Labour of the People* (the publication of which began in 1889) to investigate the nature, prevalence and causes of poverty in his own native city.†

The results of Booth's investigations had shocked the conscience of the well-to-do classes and contributed to the gradual introduction of minimum wages in the "sweated industries" and to the reforms which half a century later were incorporated in the programme of the Welfare State. Rowntree's study showed that the causes of destitution and distress were not peculiar to London. Rather unfortunately he contended that in York as in London about 30 per cent. of the population were living in a condition of "poverty", and this led to propagandist assertions that nearly one-third of the nation were without sufficient means of living.

That there had been no improvement in the twelve years between the dates of the London and York investigations was *a priori* improbable, since average wages in England had risen some 20 per cent., prices had fallen slightly, and in 1899 unemployment was much less prevalent than in the bad years preceding 1887. In fact, the apparent equality has been shown to be illusory, for the definitions of Booth's Classes A and B (*casual* and *very poor*) and C (*poor*) do not correspond to Rowntree's *primary* and *secondary* poverty.

Only careful study of the meticulous definitions and descriptions published in both cases can show to what extent the various percentages given by the two authors relate to the same objectives. While Booth depended on the visible evidences of poverty as recorded by school teachers and others, with some reference to the apparent income of each household, Rowntree computed a minimum standard based on physical needs of persons , as estimated in recent investigations by physiologists. Working on current prices in York in 1899 for ordinary food, he calculated the minimum cost of a diet that would yield the necessary calories for each household, and added the least cost of clothing, fuel, minor necessaries, and rent. Thus the first "poverty line" was established. Further, in a relatively small city such as York it was possible to visit every working-class house and estimate its economic condition‡. Finally, poverty was described as *primary* where income was insufficient for

* He was not a Fellow of the Society.

† "The inquiry of which I am now able to publish the results, was set on foot in 1886, the subject being the condition and occupations of the inhabitants of London". *Life and Labour of the People, Vol. I*; Opening words. Charles Booth: "My object in undertaking the investigation detailed in this volume was, if possible, to throw some light upon the conditions which govern the life of the wage-earning classes in provincial towns and especially upon the problem of poverty". *Poverty: A Study of Town Life*. Introduction. B. S. Rowntree.

‡ The extreme care with which each household was examined is shown in a pamphlet (*The Poverty Line. A Reply*) issued to meet Mrs. Bosanquet's criticisms of the apparent insufficiency of the method of ascertaining income.

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needs however well spent, and *secondary* where income was theoretically sufficient but expenditure faulty from this point of view.

Rowntree, much impressed by the considerable number of wage-earners where wages were too low for minimum needs, presently turned to the question, what was the least income that would provide a reasonable margin for satisfying other than purely physical wants. New minima were estimated in *The Human Needs of Labour*, 1918, (*revised in* 1937). At the latter date 53*s*. was estimated as the wage needed to satisfy the primary wants, as set out in the 1899 enquiry (with some allowance to include necessary vitamins) and to leave 9*s*. weekly for "personal sundries".* This sum (related to a man, wife and three children) provided a reasonable living wage, and "An industry which cannot afford a reasonable living wage is in an unhealthy condition." This standard, 53*s*., was approximately the normal rate for a builder's labourer in York at that date.

In order to test the adequacy of investigation by sample Rowntree took the 16,362 schedules of his 1937 enquiry (*Poverty and Progress*, 1941, pp. 478-491), and, taking successively samples of 1 in 10, 1 in 20, 1 in 30, 1 in 40 and 1 in 50, compared the results in many cases with the total number of observed. So far as I know, this is the most complete comparison of the kind that has been published. The results, which were closely in accord with mathematical theory, are summarized in *The Economic Journal*, Dec., 1941, p. 476, footnote.

In his final investigation (*Poverty and the Welfare State*,—Rowntree and Lavers, 1951) a sample of 1 in 9 was taken. The results were compared with those of the 1937 enquiry. The purpose of this small book was "to throw light on the question of how far the various welfare measures which have come into force since 1936 had succeeded in reducing poverty." This is less complete than his former studies, and though comparison is easy with the 1937 investigation, it is very difficult to carry it back to 1899, owing to some change in the setting of the Poverty Line.

These three accounts of York constitute a major contribution to sociological knowledge of the change in conditions and economic position of the so-called working classes over half a century.

Among the facts disclosed were the large proportion of children and of old people classed as in primary poverty. As to the latter, the adequacy of old age pensions is discussed in detail in *Poverty and Progress*, 1941, pp. 66 *seq*. Both in *Human Needs* and in *Poverty and Progress* considerable space is devoted to estimating the relative number of children who at one age or another will be in families below the Poverty Line ,which is greater than that in an instantaneous survey. This includes an analysis of the numbers that would be left in poverty if a minimum wage were fixed that was adequate for a family with three children, and an estimate of the expense of child allowances. Other mainly statistical publications were agricultural—*How the Labourer Lives*, 1913 (Rowntree and Kendall), and *Life and Labour, Lessons from Belgium*, 1910; and, in connection with the question of fixing a minimum wage for women, *The Responsibility of Women Workers for Dependents* (with D. Stuart), 1921. *English Life and Leisure*, 1951 (with G. R. Lavers) is in one sense a sequel to *Human Needs of Labour*, but its form is descriptive (largely of individuals' habits) rather than statistical.

Rowntree's interest in statistics was as an instrument for analyzing social questions, so as to estimate the amount of the unsatisfied needs of the working class and the causes of poverty, and to consider remedial action. As a practical philanthropist, and an employer, he followed his family tradition, and that of the Society of Friends, in his own environment, and in connection with the Cocoa Works of which he was vice-Chairman from 1925, and subsequently Chairman. But his interests were national. In the first world war he was director of the Department of Health and Welfare (appointed by Lloyd George) in the Ministry of Munitions. Subsequently he was a member of many official committees. In particular he studied the problem of unemployment. In 1911 he published *Unemployment: A Social Study* (Rowntree and Lasker). - In the depression which followed the inflation of 1920, he organized a committee of experts to measure, and suggest remedies for, the disorganization of employment. The reports of this committee were published as *The Third Winter of Unemployment* 1922; *Is Unemployment Inevitable?* 1924, and *Unemployment Insurance in Great Britain. A Critical Examination*, 1925.

This account by no means covers all Rowntree's activities, nor does it refer to the efficient genial and lighthanded method with which he encouraged and stimulated his numerous colleagues and co-workers.

A. L. Bowley.

* At 1936 prices in York.

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STATISTICAL AND ECONOMIC ARTICLES IN RECENT PERIODICALS

UNITED KINGDOM—

Accounting Research—

October 1954—The assessment of a project in the heavy chemical industry: *R. B. Peacock.* Stock changes as a factor in demand: *A. M. Alfred* and *R. E. Utiger.* Cost, price, profit and volume reactions: *K. C. Banerjee.*

Advancement of Science—

September 1954—The changing structure of the British economy: *E. A. G. Robinson.*

Annals of Human Genetics—

November 1954—Seasonal variation in the Indian deathrate: *D. D. Kosambi* and *S. Raghavachari.* Le niveau intellectuel des enfants d'une même famille: *L. Tabah* and *J. Sutter.* Checks on the calculation of the main effects and interactions in a 2^s factorial experiment: *M. H. Quenouille.*

Biometrika—

December 1954—The design of an experiment in which certain treatment arrangements are inadmissible: *D. R. Cox.* The estimation of location and scale parameters from grouped data: *J. M. Hammersley* and *K. W. Morton.* Transformations of the binomial, negative binomial, Poisson and χ^2 distributions: *G. Blom.* A quickly convergent expansion for cumulative hypergeometric probabilities, direct and inverse: *M. E. Wise.* The quotient of a rectangular or triangular and a general variate: *S. R. Broadbent.* An estimation problem in quantitative essay: *J. Aitchison* and *J. A. C. Brown.* The use of the Hankel transform in statistics. II. Methods of computation: *R. D. Lord.* A reduction formula for normal multivariate integrals: *R. L. Plackett.* On the comparison of two means: further discussion of iterative methods for calculating tables: *W. H. Trickett* and *B. L. Welch.* Some further results in the theory of pedestrians and road traffic: *A. J. Mayne.* Bias in the estimation of autocorrelations: *F. H. C. Marriott* and *J. A. Pope.* Note on bias in the estimation of autocorrelation: *M. G. Kendall.* Tests of hypotheses in the linear autogressive model. I. Null hypothesis distributions in the Yule scheme: *G. M. Jenkins.* Some problems of optimum sampling: *P. N. Somerville.* A test for Markoff chains: *P. G. Hoel.* On stationary processes in the plane: *P. Whittle.* The goodness of fit of frequency distributions obtained from stochastic processes: *V. N. Pantankar.* The distribution of range in certain non-normal populations: *H. A. David.* The mean and coefficient of variation of range in small samples from non-normal populations: *D. R. Cox.* The distribution of the ratio, in a single normal sample, of range to standard deviation: *H. A. David, H. O. Hartley* and *E. S. Pearson.* Sampling with control variables: *E. C. Fieller* and *H. O. Hartley.* Rank analysis of incomplete block designs. II. Additional tables for the method of paired comparisons: *R. A. Bradley.* Approximate formula for the percentage points and the probability integral of the non-central χ^2 distributions: *S. H. Abdel-Aty.* Moments of the mean deviation: *A. R. Kamat.* On the relation between estimating efficiency and the power of tests: *R. M. Sundrum.* The interpretation of negative components of variance: *J. A. Nelder.* The distribution of the regression coefficient in samples from a non-normal population: *I. D. Hill.*. Probability distributions arising from points on a line: *P. V. Krishna Iyer* and *M. N. Kapur.* The factorial moments of the distribution of joins between line segments: *J. Wishart.* Note on the use of Sherman's statistic as a test for randomness: *D. J. Bartholomew.* Two early papers on the relation between extreme values and tensile strength: *J. Lieblein.* Two problems in sets of measurements: *M. G. Kendall.*

British Journal of Sociology—

September 1954—Attendance and absence in industry: the nature of the evidence: *R. B. Buzzard.*

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Cambridge Philosophical Society Proceedings—

October 1954—An alternative method for linear programming: *E. M. L. Beale.* The numerical solution of Poisson's and the bi-harmonic equations by matrices: *A. F. Cornock.* The calculation of the latent roots and vectors of matrices on the pilot model of the A.C.E.: *J. H. Wilkinson.* The statistics of scaled random events: *R. O. Davies* and *J. W. Leech.* The expected number of clumps when convex laminae are placed at random and with random orientation on a plane area: *C. Mack.* On multiple returns in the random-walk problem: *C. Domb.*

Economic Journal—

September 1954—The changing structure of the British economy: *E. A. G. Robinson.* Increasing productivity, income-price trends and the trade balance: *H. G. Johnson.* The 1948–49 American recession: *C. A. Blyth.* Linear expenditure systems and demand analysis: an application to the pattern of British demand: *J. R. N. Stone.*

Economica—

November 1954—Economics of dependence (1952–82): *F. W. Paish* and *A. T. Peacock.* Industrial productivity growth in Europe and in the U.S.: *A. Maddison.*

Heredity—

August 1954—A fuller theory of "junctions" in inbreeding: *Sir R. Fisher.*

Manchester School of Economic and Social Studies—

September 1954—Statistics of United Kingdom terms of trade: *E. Devons.* The co-ordination of public passenger transport in South-east Lancashire: *G. M. Higgins* and *W. J. M. Mackenzie.*

Oxford University Institute of Statistics Bulletin—

September–October 1954—The structure of engineering earnings: *K. G. J. C. Knowles* and *T. P. Hill.* The shipping bill for British imports: *A. Romanis.*

INDIA—

Calcutta Statistical Association Bulletin—

June 1954—Indian Science Congress Session—proceedings of the Statistics Section. Absenteeism in Indian industries: *M. V. Venkataraman.* On equally correlated processes: *K. Nagabhushanam* and *V. K. Murty.* A.R.B.I.B. designs and non-singular GD designs: *S. S. Shrikhande.* A note on *t* test for paired samples: *V. P. Bhapkar.*

Sankhya—

September 1954—The technique of social accounting in a pre-industrial economy: *M. Mukherjee.* Analytic tests and confidence intervals for the mean value, probabilities, and percentage points of a Poisson distribution: *J. E. Walsh.* On the method of inversion in the construction of partially balanced incomplete block designs from the corresponding B.I.B. designs: *P. M. Roy.* A note on minimum variance in unbiased estimation: *S. K. Mitra.* On some problems in canonical correlations: *R. G. Laha.* On the problem of screening defective articles during production: *M. Masuyama.* The most powerful unbiased critical regions and the shortest unbiased confidence intervals associated with the distribution of classical D^2- statistic: *S. B. Chowdhury.* A short note on wagon turn-round: *J. Singh.* National Sample Survey: the third round. Truncated sampling from distributions admitting sufficient statistics: *D. Raj.* Note on the design of experiments and testing the efficiency of drugs having local healing power: *K. K. Mathen.*

NEW ZEALAND—

Royal Society of New Zealand, Transactions—

June 1954—Variation in a sample of *pinus radiata* cones from the Nelson district: *M. H. Bannister.*

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UNION OF SOUTH AFRICA—

South African Journal of Economics—

September 1954—Sampling technique in an economic survey of sugar cane production: *H. I. Behrmann.*

UNITED STATES—

American Statistical Association, Journal—

September 1954—A quarterly model for the U.S. economy: *H. Barger* and *L. Klein.* Co-ordinating the U.S. statistical system: *S. A. Rice.* Growth by merger: *G. W. Nutter.* Spurious correlation: a causal interpretation: *H. A. Simon.* Empirical study of the accuracy of selected methods of projecting state populations: *H. R. White.* Interpreting mortality after retirement: *R. J. Myers.* Sampling control of literacy data: *S. S. Zarkovic.* Response errors in estimating value of homes: *L. Kish* and *J. B. Lansing.* Comparison of stratified two-stage sampling system: *A. R. Sen, R. L. Anderson* and *A. L. Finkner.* Combining independent tests of significance: *A. Birnbaum.* Minimum life in fatigue: *A. M. Freudenthal* and *E. J. Gumbel.* Point estimates of ordinates of concave functions: *C. Hildreth.* Approximate distribution of the range in the neighbourhood of low percentage points: *M. H. Belz* and *R. Hooke.* Optimum grouping in one-criterion variance components analysis: *E. P. King.* Statistical Abstracts.

American Statistician—

October 1954—The training of statisticians: *G. E. Nicholson, Jr.*

Biometrics—

September 1954—Decision between two alternatives—how many experiments?: *P. M. Grundy, D. H. Rees* and *M. J. R. Healy.* The analysis of experiments containing different crop rotations: *F. Yates.* The derivation of joint distribution and correlation between relatives by the use of stochastic matrices: *C. C. Li* and *L. Sacks.* A stochastic model for the selection of macronuclear units in paramecium growth: *A. W. Kimball* and *A. S. Householder.* Incomplete block rank analysis: on the appropriateness of the model for a method of paired comparisons: *R. A. Bradley.* Incomplete block rank analysis: some taste test results: *J. W. Hopkins.* A note on missing plot values: *J. A. Nelder.* A note on truncated Poisson distributions: *P. G. Moore.*

Estadística—

September 1954—Aspectos Metodológicos del Censo Experimental de Población, Viviendas y Enfermedades en Huacho, Perú, 1952: *J. A. Cavanaugh* and *C. A. Uriarte.* Agricultural sample survey of the province of Pichincha, Ecuador, 1952: *R. J. Jessen.* Apreciación de Cuatro Reuniones Nacionales sobre Coordinación Estadística: *Omar Dengo O.* Encuesta Agropecuaria de Nicaragua, 1952: *Enrique Lanzas B.* Planeamiento y Alcances Técnicos del Experimento Venezolano sobre un Sistema de Estadísticas Vitales: *R. Garcia-Frias.*

Harvard Business Review—

September–October 1954—Big costs of little fringes: *A. M. Fisher and J. F. Chapman.* The new science of records management: *R. A. Shiff* and *A. Barcan.*

December 1954—Economic challenge of longevity: *A. W. Rucker.*

Industrial Quality Control—

November 1954—Cost of quality: *W. H. Lesser.* Some quality control applications in the aluminium company of America: *W. P. Goepfert.* *F* table significance tests for two small-sample means: *D. R. Howes.* Pretesting packaged products for safe transit—a vital phase of quality control: *R. F. Bisbee.* Some experience with the design of experiments: *J. R. Duffett.*

Operations Research Society of America, Journal—

November 1954—Military decision and game theory: *O. G. Haywood, Jr.* Training for operations research: *J. F. McCloskey.* Solution of a large-scale travelling salesman problem: *G. Dantzig, R. Fulkerson* and *S. Johnson.* Industrial economics and operations

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research at Stanford Research Institute: *W. J. Platt.* Optimum operation of a complex activity under conditions of uncertainty: *M. J. Solomon.* Numerical solution of the problem of optimum distribution of effort: *W. Miehle.*

Psychometrika—

September 1954—An analytical method for simple structure: *L. L. Thurstone.* A method for the study of interstimulus similarity: *C. H. Coombs.* Two kinds of factor analysis: *R. E. Hartley.* A simple proof of a personnel classification theorem: *H. E. Brogden.* Changes in factor structure of a complex psychomotor test as a function of practice: *E. A. Fleishman* and *W. E. Hempel, Jr.* A computing chart for the point biserial correlation coefficient: *H. F. Dingmam.*

Review of Economics and Statistics—

November 1954—Mathematics: logic, quantity, and method: *D. Novick*, Mathematics in economics: Discussion of Mr. Novick's article.

EGYPT—

L'Egypte Contemporaine—

July 1954—Econometric approach to certain agricultural problems in Egypt: *O. Wahby.*

FRANCE—

Journal de la Société Statistique de Paris—

April–June 1954—Les fluctuations de la production industrielle et de l'emploi dans l'industrie depuis 1914. Deux aspects du mouvement économique de longue durée: *L. Flaus.* Utilization de l'échelle "arc-tangente" comme échelle des temps: *M-L.* and *J. Dufrénoy.* L'échelle "arc-tangente" et la représentation du temps biologique: *J. Dufrénoy.* Anamorphose de courbe sigmoïde par utilization d'une échelle arc-tangente: *M-L.* and *J. Dufrénoy.*

GERMANY—

Weltwirtschaftliches Archiv—

Vol. 73, Part 1—Der Realismus der Marginalananalyse in der Preistheorie: *E. Schneider.* Multiplikator, Akzelerator, Wachstumsraten und Konjunkturzyklus. Eine kritische Betrachtung der jüngsten Entwicklung der Konjunkturtheorie: *W. Kraus.* Bevölkerungsentwicklung und Leistungspotential: *K. M. Bolte.*

JAPAN—

Reports of Statistical Application Research, Union of Japanese Scientists and Engineers—

March 1954—A table of the power function of the analysis of variance tests: *S. Ura.* Confidence limits for a variance component: *S. Moriguti.* Further discussions on mother-child combinations, concerning an inherited character after a panmixia: *Y. Komatu.* On the unification of two approximations of a noncentral *F*-distribution: *M. Masuyama.*

SWITZERLAND—

Schweizerische Zeitschrift für Volkswirtschaft und Statistik—

September 1954—Ein internationales Schema für Volkswirtschaft und Statistik: *U. Zwingli.* Sample surveys for household income and expenditure information: *J. E. G. Utting.* Genfer Volks- und Berufszählungen des 18. Jahrhunderts: *E. J. Walter.*

INTERNATIONAL—

World Health Organization Bulletin—

Vol. 11, No. 1–2—The use of sampling for vital registration and vital statistics: *P. M. Hauser.* The use of sampling methods for ascertaining the total morbidity in the Canadian Sickness Survey, 1950–1: *F. Fraser Harris.* Problems of confidentiality in reporting morbidity and causes of death: *M. G. Neurdenburg.* Le secret des informations at les statistiques sanitaires: *M. J. Aubenque.* Securing co-operation from persons supplying statistical data: *M. J. Aubenque, R. M. Blaikley, F. Fraser Harris, R. B. Lal, M. G. Neurdenburg* and *R. de S. Hernandez.* Securing wide appreciation of health statistics: *A. M. do A. Pyrrait. M. J. Aubenque, B. Benjamin, J. W. de G. Meindert* and *R. Kohn.* Needs in vital and health statistics in underdeveloped countries: *P. Stocks.* Objectives underlying future patterns of work of national committees on vital and health statistics: *H. L. Dunn.*

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LIST OF ADDITIONS TO THE LIBRARY

Since the issue of Part 4, 1954, the Society has received the publications enumerated below.

I.—OFFICIAL PUBLICATIONS

United Kingdom. *Board of Trade.* Report of the Committee on the Censuses of Production and Distribution ... London, H.M.S.O., 1954. iv, 43p. 9½″. 1*s.* 6*d.* Cmd. 9267.

General Register Office. Measurement of morbidity : a report of the statistics sub-committee of the Registrar General's advisory committee on medical nomenclature and statistics. London, H.M.S.O., 1954. iii, 12p. 9¾″. 1*s.* 6*d.* (Stud. Med. & Pop. Subj. 8.)

Census 1951 England and Wales : County report ... Berkshire. xliv, 54p. 17*s.* 6*d.* Brecknockshire and Carmarthenshire. xlvi, 62p. 20*s.* Cumberland and Westmorland. xliv, 64p. 20s. Derbyshire. xlvi, 72p. 21*s.* Monmouthshire. xliv, 59p. 20*s.* Northamptonshire. xlviii, 68p. 20*s.* Nottinghamshire. xlvi, 54p. 17*s.* 6*d.* Yorkshire East and North Ridings. liv, 118p. 27*s.* 6*d.* London, H.M.S.O., 1954. 13″.

Lord Chancellor's Department. County Courts Branch. Index to the parishes, townships, hamlets & places contained within the districts of the several county courts in England and Wales. 8th ed. London, H.M.S.O., 1954. [iii], 218p. 12¾″. 20*s.*

Medical Research Council. Intracranial gliomata: some clinical radioligocal and therapeutic aspects of 298 cases; John Penman and Marion C. Smith. London, H.M.S.O., 1954. v, 70 p. 9½″. 5*s.* (Spec. Repr. Ser. 284.)

Studies on the nutritive value of bread and on the effect of variations in the extraction rate of flour on the growth of undernourished children; E. M. Widdowson and R. A. McCance. London, H.M.S.O., 1954. viii, 137p. 9½″. 8*s.* 6*d.* (Spec. Repr. Ser. 287p.)

Ministry of Agriculture and Fisheries. Costs and efficiency of pig production: a comparison between England and Denmark: report of an investigation made in collaboration with the University of Nottingham. London, H.M.S.O., 1954. iv, 45p. illus. 9½″. 2*s.*

Ministry of Education. The organisation and finance of adult education in England and Wales: report of the committee appointed by the Minister of Education in June, 1953. London, H.M.S.O., 1954. iv, 67p. 9½″. 2*s.* 6*d.*

Ministry of Fuel and Power. Pneumoconiosis in the mining and quarrying industries: digest of statistics, 1953. London, H.M.S.O., 1954. 80p. 9½″. 2*s.* 6*d.* Cmd. 9322.

Ministry of Housing and Local Government. Committee on air pollution report ... London, H.M.S.O., 1954. 80p. 9½″. 2*s.* 6*d.* Cmd. 9322.

Ministry of Pensions and National Insurance. Memorandum on the National Insurance Bill, 1954, and report by the Minister ... on his review of the rates and amounts of national insurance benefit ... London, H.M.S.O., 1954. 8p. 9½″. 4*d.* Cmd. 9338.

National Assistance Act, 1948. Explanatory memorandum on the Draft National Assistance (Determination of Need) Amendment Regulations 1954 ... London, H.M.S.O., 1954. 4p. 9½″. 3*d.* Cmd. 9334.

National Insurance Bill, 1954. Report by the Government Actuary on the financial provisions of the bill ... London, H.M.S.O., 1954. 8p. 9½″. 4*d.* Cmd. 9332.

National Insurance retirement pensions, reasons given for retiring or continuing at work: report of an inquiry ... London, H.M.S.O., vi, 136p. 9½″. 5*s.*

Monopolies and Restrictive Practices Commission. Report on the supply of buildings in the Greater London area ... London, H.M.S.O., 1954. iv, 115p. 9½″. 3*s.* 6*d.*

National Physical Laboratory. Automatic digital computation: proceedings of a symposium held at the National Physical Laboratory on March 25, 26, 27 & 28, 1953. London, H.M.S.O., 1954. [ii], vi, 296p. photos, diagrs. 10½″. 21*s.*

Scotland. Department of Health. Rents of houses owned by local authorities in Scotland, 1953. Edinburgh, H.M.S.O., 1954. 40p. 9½″. 1*s.* 9*d.* Cmd. 9235.

Scotland. General Registry Office. Life tables, 1950–52: supplement to the ninety-ninth annual report of the Registrar General for Scotland. Edinburgh, H.M.S.O., 1954. 24p. 9½″. 1*s.* 3*d.*

Census 1951: report on the fifteenth census of Scotland ... Vol. I—Part 26. Counties of Perth and Kinross. 68p. 18*s.* 6*d.* Part 27. County of Renfrew. 53p. 12*s.* Part 28. County of Ross and Cromarty. 44p. 11*s.* Part 29. County of Roxburgh. 40p. 10*s.* Part 30. County of Selkirk. 34p. 8*s.* Part 31. County of Stirling. 47p. 11*s.* 6*d.* Part 32. County of Sutherland. 31p. 7*s.* 6*d.* Edinburgh, H.M.S.O., 1954. 13″.

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Treasury. National Insurance Act, 1946. Report by the Government Actuary on the first quinquennial review ... London, H.M.S.O., 1954. iii, 60p. fol. tab. 9½″. 2*s*. 6*d*.

A report by the Government Actuary and the Actuary to the National Debt Commissioners on the mortality experience of government life annuitants, 1940–1950. London, H.M.S.O., 1954. 14p. 9½″. 6*d*.

Report of the Committee on the economic and financial problems of the provision for old age ... London, H.M.S.O., 1954. iii, 120p. 9½″. 4*s*. Cmd. 9333.

Australia. *Commmonwealth Bureau of Census and Statistics*. Report on the food production and the consumption of foodstuffs and nutrients in Australia, No. 8, 1952–53 ... Canberra, 1954. 49p. 13″.

Canada. *Dominion Bureau of Statistics*. Ninth census of Canada 1951: Vol. VIII: Distribution, wholesale trade services. Vol. VII: Distribution, retail trade. Ottawa, 1954. 2 vols. 11″. $3 each.

Eire. *Central Statistics Office*. Household budget inquiry, 1951–52. Dublin, Stationery Office, 1954. li, 135p. 12¾″. 6*s*.

Finland. *Statistiska Centralbyrån*. Maatalous. Yleinen maatalouslaskenta V. 1950. The 1950 census of agriculture. Helsinki, 1954. 4 vols. 11¾″. (Finlands Officiella Statistik.)

Food and Agriculture Organization. Estimation of crop yields; by V. G. Panse ... Rome, F.A.O., 1954. [iv], ii, 61p. 9″. 2*s*. 6*d*.

Grain exports by source and destination, July 1953–June, 1954. Rome, F.A.O., 1954. (London, H.M.S.O.) 22p. 11″. 1*s*. 3*d*.

France. *Institut National de la Statistiques et des Études Économiques*. Résultats statistiques du recensement général de la population effectué le 10 mars 1946. Vol. II: Population présente totale. Vol. III. Population active, deuxième partie, Etrangers et naturalisés. Vol. VI. Habitations, premiére partie, Immeubles. Paris, Imprimerie Nationale, 1953. 3 vols. 10½″.

Direction de l'Administration Departementale et Communale. Institut National de la Statistique et des Études Économiques. Recensement de 1954, population de la France: Départements, arrondissements, cantons et communes (metropole). Paris, Imprimerie Nationale, 1954. 985p. 10½″.

Germany. *Statistisches Bundesamt*. Die Bevölkerung der Bundesrepublik Deutschland nach der Zählung vom 13.9.1950. Heft 7. Fläche und Bevölkerung der naturräumlichen Einheiten. Heft 8. Die Struktur der Haushaltungen (Ergebnisse repräsentativer Sonderauszahlungen aus dem Material der Volkszählung vom 13.9.1950). Stuttgart-Koln, W. Kohlhammer, 1954. 2 vs. maps. 11¾″. (S.B.D. 35.)

Federal statistics: the activities of the Federal Statistical Office and the statistics processed by the Supreme Federal Authorities, position on 31 December, 1953. Stuttgart-Cologne, W. Kohlhammer, 1954. 88p. 11¾″. (Stats. Fed. Repbl. Germany 82.)

India. *Ministry of Home Affairs. Office of the Registrar General*. Census of India 1951: Displaced persons. 175p. 2*s*. 9*d*. (Census Papr. 4.) Estimation of birth and death rates in India during 1941–50. iii, 64p. 1*s*. 6*d*. (Census Papr. 6.) New Delhi, 1954. 10¾″.

Census of India 1951: Volume I. India, Part II B. Economic tables, general population. New Delhi, 1954. xxvii, 466p. 11″. 16*s*.

Japan. *Bureau of Statistics*. Population census of 1950. Vol. IV: Vol. VI. Tokyo, 1954. 2vs. 10¼″.

Mozambique. *Repartição Técnica de Estatística*. Recenseamento geral da população em 1950 II: inventário das edifições e fogos. Lourenço Marques. 1954. 39p. 10½″.

New Zealand. *Census and Statistics Department*. Population census, 1951. Vol. IV. Industries, occupations and income. Vol. VII. Dwellings and households. Wellington, 1954. 2 vs. 12″.

Report on the official estimates of balance of payments of New Zealand for the years, 1950–51 to 1953–54. Wellington, 1954. 36p. tabs. 12″.

Report on the official estimates of national income and sector accounts of New Zealand for the years, 1938–39 to 1953–54. Wellington, 1954. 55p. 12″.

Norway. *Statistisk Sentralbyrå*. Dødelighetstabeller for det Norske folk, 1946–1950. Life tables according to the mortality experiences, 1946–1950. Oslo, 1954. 65p. 9½″. (Norges Offisielle Statistikk XI.182.)

Fengselsstyrets årbok, 1931–1950. Report of the prison administration. Oslo, 1954. 148p. 9½″. (N.O.S. XI. 172.)

Folkemengden I herrider og byer 1 Januar, 1953. Population in rural districts and towns January 1, 1953. Oslo, 1954. 41p. 8½″. (N.O.S. XI. 171.)

Statistikk over landssvik, 1940–1945. Statistics on treason and collaboration, 1940–1945. Oslo, 1954. 64p. 9½″. (N.O.S. XI. 179.)

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Organisation for European Economic Co-operation. Economic conditions in:—Austria, Switzerland; Belgium, Luxemberg and the Netherlands. Canada and the United States. Denmark, Iceland, Norway. Ireland, Portugal. Italy. United Kingdom. Paris, O.E.E.C., 1954. 7 vols. 9½″.

Private United States investment in Europe and the overseas territories. Paris, O.E.E.C., 1954. 137p. 9½″. 8*s*.

Report by the economic committee of O.E.E.C. on the pattern of Western European trade, 1948–1953. Paris, 1954. iii, 64p. (typewritten) 3 tabs. 10¾″.

Punjab (Pakistan). *Board of Economic Inquiry.* Statistical abstract of the Punjab, 1947 to 1953. Lahore, Board of Economic Inquiry, 1954. x, 258p. 9¾″. *Rs.* 5. (Publ. 107.)

Sweden. Levnadskostnader och reallöner i de Nordiska huvudstäderna. Stockholm, 1954. 92p. 9¾″. (Nordisk Statistisk Skriftserie. 1.)

Försäkringsinspektionen. Enskilt forsakringsvasen hur det vuxit fram hur det overvakas beskrivet av forsakringsinspektionen. (Private insurance in Sweden: how it has developed and how it is being supervised.) Stockholm, 1954. 117p. photos, diagrs. 9½″.

Statistiska Centralbyrån. Dödlighets och livslängdstabeller för årtiondet, 1941–1950. Stockholm, 1954. x, 69p. (Sveriges Officiella Statistik.)

Switzerland. *Eidgenössisches Statistiches Amt.* Eidgenössische Volkszählung 1. Dezember 1950. 8: Kanton Glarus. 106p. 9: Kanton Graubünden. 150p. 16: Kanton Thurgau. 142p. 20: Canton du Valais. 134p. 23: Kanton Zug. 108p. Bern, 1954. 5 vs. 11¾″. (Statistische Quellenwerke 257, 260, 261, 263, 264.)

Union of South Africa. *Bureau of Census and Statistics.* Census of the population of the Union of South Africa, enumerated 7th May, 1946. Vol. IV: Languages and literacy. Pretoria, 1953. vi, 153 p. 12″. 14*s*.

United Nations. *Department of Social Affairs. Population Division.* Foetal, infant and early childhood mortality: Vol. I: The statistics. New York, 1954. vi, 137p. 11″. 11*s*. (Pop. Stud. 13.)

Educational Scientific and Cultural Organization. International bibliography of political science (works published in 1952). Paris, U.N.E.S.C.O., 1954. 248p. 9½″. 17*s*. 6*d*. (Documentation in the Social Sciences.)

The university teaching of the social sciences: sociology, social psychology and anthropology; reports prepared by Pierre de Bie ... and others. 252p. 8½″. 10*s*. 6*d*. (Teaching in the Social Sciences.)

United States of America. *National Bureau of Standards.* Table of sine and cosine integrals for arguments from 10 to 100. Washington, Supt. of Documents, 1954. xv, 187p. 10¼″. $2.25. (Appl. Math. Ser. 32.) A re-issue of Mathematical Tables 13.

Table of the gamma function for complex arguments. Washington, Supt. Documents, 1954. xvi, 105p. 10¾″. $2. (Appl. Math. Ser. 34.)

II.—AUTHORS AND MISCELLANEOUS

Abdel-Aty, S. H. Tables of generalized *k*-statistics. *Biometrika* (1954), **41**, 253–260. 10¾″. 2*s*. (New Statistical Tables 19.)

American Meteorological Society and Royal Meterological Society. Proceedings of the Toronto Meteorological Conference, 1953, held from 9 to 15 September, 1953. London, Royal Meteorological Society, 1954. iv, 294p. 10″. 30*s*.

Angelo, Pasquale d' & Mazzantini, Mario. Trattato di tecnica bancaria; 6th ed. Milano, Casa Editrice Dottore Francesco Vallardi, 1954. xxv, 1045p. tabs. 9¾″.

Anscombe, F. J. & Page, E. S. Sequential tests for binomial and exponential populations. *Biometrika* (1954), **41**, 252–253. 11″.

Armitage, P. Sequential tests in prophylactic and therapeutic trials. *Quart. J. Med.* (1954), **23**, 255–274. 10¾″.

Bell, D. A. Information theory and its engineering applications. London, Pitman, 1954. vii, 138p. 8½″. 20*s*.

Blank, David M. The volume of residential construction, 1889–1950. New York, National Bureau of Economic Research, 1954. xii, 99 p. 10¾″. (N.B.E.R. Tech. Papr. 9.)

Bonham, John. The middle class vote. London, Faber & Faber, 1954. 210p. illus. 8½″. 21*s*.

Borenstein, Israel. Capital and output trends in mining industries, 1870–1948. New York, National Bureau of Economic Research, 1954. [xi] 81p. 9″. $1. (Studies in Capital Formation and Financing. Occ. Papr. 45.)

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British Productivity Council. Report of a conference with the chairmen of local productivity committees held at 21, Tothill Street, London, S.W.1. on Tuesday, 28th July 1953. London, 1953. iii, 47p. 8½″.

Cambridge University. Department of Applied Economics. Some aggregation problems in demand analysis. M. J. Farrell. *Rev. Econ. Stud.* (1954), **21**, 193–203. 9¾″. (Repr. Ser. 81.)

Linear expenditure systems and demand analysis: an application to the pattern of British demand; Richard Stone. *Econ. J.* (1954), **44**, 511–527. 9½″. (Repr. Ser. 82.)

The demand for motor-cars in the United States; M. J. Farrell. *J. Roy. Statist. Soc.* (1954), A, **117**, 171–201. 9½″. (Repr. Ser. 83.)

Campbell, W. A. B. & Cheeseman, E. A. Breast feeding in Co. Armagh and Belfast: an attempted comparison. *Med. Offr.* (1954), **92**, 251–252. 12″.

Catania University. Studi di economia e statistica. Catania, Sicily, 1950–1952, 2 vols. 9½″. (Pubb. della Fac. Econ. Comm. Ser. 1. V. 1 & 2.)

Chalmers, Henry. World trade policies: the changing panorama, 1920–1953, a series of contempory periodic surveys. Berkeley and Los Angeles, Univ. California Press, 1953. (Cambridge Univ. Press.) xxxvii, 546p. 9¼″. 54*s.* 6*d.*

Chartered Bank of India, Australia and China. 1853–1953. [London 1954]. 39p. tabs. diagrs. 9¾″.

Chaundy, T. W. *and others.* The printing of mathematics: aids for authors and editors and rules for compositors and readers at the University Press, Oxford. Oxford, O.U.P., 1954. (London, Geoffrey Cumberlege.) ix, 105p. illus. 9¼″. 15*s.*

Chisholm, George G. Chisholm's handbook of commercial geography; entirely re-written by L. Dudley Stamp ... and S. Carter Gilmour. 14th ed. ... London, Longmans Green, 1954. xiii, maps, diagrs. 8½″. 60*s.*

Collier, Adam. The crofting problem. London, C.U.P., 1953. xv, 191p. photos. 9″. 25*s.* (Glasgow Univ. Dept. Soc. & Econ. Res. Soc. & Econ. Stud. 1.)

Cox, D. R. Note on the formal use of complex probabilities in the theory of stochastic processes. *Proc. Int. Math. Congr. Amsterdam* (1954), **1**, 1. 10¾″.

Cox, D. R. & Smith, Walter L. On the superposition of renewal processes. *Biometrika* (1954), **41**, 91–99. 10¾″.

Cuisenaire, G. & Gattegno, C. Numbers in colour: a new method of teaching arithmetic in primary schools. London, Heinemann, 1954. viii, 39p. tabs. 8½″. 4*s.* 6*d.*

Curwen, M. P. Punched cards for routine in-patient records. *Hospital* (1954), 433–442, 9″.

Curwen, M. P. *and others.* The incidence of cancer of the lung and larynx in urban and rural districts. *Brit. J. Cancer* (1954), **8**, 181–198. 9¾″.

Elderton, William Palin. Frequency curves and correlation. 4th ed. [Cambridge University Press, 1953] xi, 272p. 8½″. 30*s.*

Eysenck, H. J. The psychology of politics. London, Routledge & Kegan Paul, 1954. xvi, 317p. 8½″. 25*s.*

Ferguson, Sheila & Fitzgerald, Hilde. Studies in the social services. London, H.M.S.O., & Longmans Green, 1954. ix, 367p. 9½″. 27*s.* 6*d.* (History of the Second World War U.K. Civil Series.)

Finney, D. J. The estimation of error in the systematic sampling of forests. *J. Indian Soc. Agric. Statist.* (1953), **5**, 6–16. 9¾″.

Fisher, Sir Ronald A. Statistical method for research workers. 12th ed. Edinburgh & London, Oliver & Boyd, 1954. xv, 356p. 8¾″. 16*s.*

Hill, A. Bradford. Medical statistics and the design of experiment. 1*st World Confr. Med. Educ.* (1953), 271–277. 9″.

Poliomyelitis in England and Wales between the wars: President's address. *Proc. Roy. Soc. Med.* (1954), **47**, 795–806. 12p. 9¾″.

Principles of medical statistics. 5th ed. London, *Lancet*, 1953. ix, 282p. 8½″. 10*s.* 6*d.*

Gayer, Arthur D. *and others.* The growth and fluctuation of the British economy, 1790–1850: an historical, statistical, and theoretical study of Britain's economic development. Oxford, Claredendon Press, 1953. 2 vols. tabs. diagrs. 9½″. 84*s.*

Glass, D. V. *editor.* Social mobility in Britain. London, Routledge & Kegan Paul, 1954. viii, 412p. 8½″. 36*s.*

Glass, D. V. & Grebenik, E. Summary chapter from the *Trend and Pattern of Fertility in Great Britain: a report on the family census of 1946*. London, printed by H.M.S.O., 1954. 12p. 12¾″.

Goldscheider, Gertrude, & Stern, E. Babette. Factors influencing the occurrence of reactions during the treatment of carcinoma of the cervix uteri by radium. *Brit. J. Radiol.* (1953), **26**, 370–376. 9¾″.

Griffin, Harriet. Elementary theory of numbers. New York & London, McGraw-Hill, 1954. ix, 203p. 9″. 36*s.*

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Hadamard, Jacques. An essay on the psychology of invention in the mathematical field. New York, Dover Publications, 1954. xii, 145p. 8″. $1.25.

Herdan, Gustav. Small particle statistics: an account of statistical methods for the investigation of finely divided materials; with a guide to the experimental design of particle size determinations; by M. L. Smith ... Amsterdam & New York, Elsevier Publishing Co., 1953. xxiii, 520p. 9″. 70*s.*

International Council for Building Research Studies and Documentation. C.I.B. bulletin, No. 2, No. 3. Rotterdam, 1954. 2 vols. 12″.

International Economic Association. International economic papers No. 4. Translations prepared for the International Economic Association; ed. by A. T. Peacock, W. F. Stolper, R. Turvey, E. Henderson. London, Macmillan, 1954. 229p. 10″. 15*s.*

International Tin Study Group. Statistical year book 1954, tin, tinplate, canning. The Hague, I.T.S.G. 260p. 10½″. 55*s.*

Isaac, Julius. British post-war migration. London C.U.P., 1954. xix, 310p. 9½″. 30*s.* (N.I.E.S.R. Occ. Papr. 17.)

Jeffreys, James B. Retail trading Britain 1850–1950: a study of trends in retailing with special reference to the development of co-operative, multiple shop and department store methods of trading. London, C.U.P., 1954. xvii, 497p. plates. 9″. 50*s.* (N.I.E.S.R. Econ. Soc. Stud. 13.)

Kantner, John F. & Kiser, Clyde V. Social and psychological factors affecting fertility. XXII. The interrelation of fertility, fertility planning, and intergenerational social mobility. *Milbank Mem. Fd. Quart.* (1954), **32**, 69–103. 969–1003p. 9″.

Kantner, John F. & Potter, Robert G. jr. Social and psychological factors affecting fertility. XXIV. The relationship of family size in two successive generations. *Milbank Mem. Fd. Quart.* (1954), **32**, 294–311. 1069–1086p. 9″.

Khajeh Nouri, A. G. *and others.* The experimental sample survey of the households of Teheran, June 20–June 24, 1954. [Teheran, Public Statistics Co-operative Organization, 1954] v, 40, 1. 13″.

Kiser, Clyde V. The Indianapolis fertility study: an example of planned observational research. *Publ. Opinion Quart.* (1953–54), **17**, 496–510. 9″.

Knorr, Klaus & Patterson, Gardener. A critique of the Randall Commission: report on United States foreign economic policy. Princeton Univ., 1954. iv, 65p. 9″.

Koya, Yoshio. A study of induced abortion in Japan and its significance. *Milbank Mem. Fd. Quart.* (1954), **32**, 282–293. 12p. 9″.

Kuznets, Simon & Rubin, Ernest. Immigration and the foreign born. New York, National Bureau of Economic Research, 1954. xii, 107p. 9″. $1.50. (N.B.E.R., Occ. Papr. 46.)

Larsson, Tage & Sjögren, Torsten. A methodological, psychiatric and statistical study of a large Swedish rural population. Copenhagen, Ejnar Munksgaard, 1954. 9½″. (Acta Psych. Neurol. Scand. Suppl. 89) Trans. Donald Burton.

Lee, William Alexander. Thirty years in coal 1917–1947: a review of the coal mining industry under private enterprise. [London], The Mining Association, 1954. 255p. 8½″. 16*s.*

Little, I. M. D. The price of fuel. Oxford, Clardendon Press, 1953. xiv, 197. 8½″. 12*s.* 6*d.*

London. St. Bartholomew's Hospital. Department of Medical Statistics. Statistical report for 1947, 1948, 1949, 1950, 1951. London, St. Bartholomew's Hospital [1948–1953]. 5 vols. 10″.

Malenbaum, Wilfrid. The world wheat economy, 1885–1939. Cambridge, Mass. Harvard Univ. Press, 1953. London C.U.P. xv, 262p. diagrs. 8½″. 48*s.* (Harvard Econ. Stud. 92.)

Martin, W. J. The age-specific death-rates in England and Wales. *J. Hyg., Camb.* (1954), **52**, 417–424. 10″.

Masuyama, Motosaburo. Graphical method of statistical inference: seminar note. Tokyo, Maruzen, 1954. [ii], ii [i], 83p. fol. tabs. 8″.

Morgenstern, Oscar, *editor.* Economic activity, analysis. New York, Wiley, 1954. (London, Chapman & Hall.) [iv], xviii, 554p. 9½″. 54*s.*

Myers, Robert J. The effect of age of mother and birth order on sex ratio at birth. *Milbank Mem. Fd. Quart.* (1954), **32**, 275–281. 9″.

National Bureau of Economic Research. Research in the capital and securities markets. New York, N.B.E.R., 1954. xii, 76p. 9″. $1. (N.B.E.R. Fin. Res. Prog.)

Netherlands. Central Planning Bureau. A customs union for Western Europe: advantages and feasibility; P. J. Verdoorn. *World Politics* (1954), **6**, 482–500. 9¼″. (Repr. Ser. 35.)
De Nederlandse concurrentiepositie op de West-Europe en Noord-Amerikaanse invoemarkten; F. Hartog. *De Economist* (1954), **102**, 19p. 9¼″. (Repr. Ser. 36.)
De financiële situatie van weduwen; J. G. M. Delfgaauw. *Econ. Stat. Berichten* (1954), **39**, 752–754. 6p. 9½″. (Repr. Ser. 37.)

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North Carolina, University of Institute of Statistics. Tables of partially balanced designs with two associate classes; by R. C. Bose, W. H. Clatworthy and S. S. Shrikhande. *North Carolina Agric. Exp. Stat. Tech. Bull.* (1954), No. 107. iv, 255p. (Repr. Ser. 50).

One man's vision: the story of the Joseph Rowntree Village Trust. London, Allen & Unwin, 1954. xii, 149p. illus. 8¾″. 10*s.* 6*d.*

Oram, Arthur Talbot. An experiment with random numbers. *J. Soc. Psych. Res.* (1954), **37**, 369–377. 8½″.

Ostle, Bernard. Statistics in research: basic concepts and techniques for research workers. Ames, Iowa State College Press, 1954. xiv, 487p. 9″. $6.95.

Page, E. S. Continuous inspection schemes. *Biometrika* (1954), **41**, 100–115. 10¾″.

The Monte Carlo solution of some integral equations. *Proc. Camb. Phil. Soc.* (1954), **50**. 10″.

Parzen Emanuel. On uniform convergence of families of sequences of random variables. Berkeley and Los Angeles. Univ. California Press, 1954. [iv], 23–53. 10¼″. (Univ. California Publ. Statistics, **2**, 2.)

Ramamurti, B. Agricultural labour, how they work and live. [New Delhi, Ministry of Labour, 1954], xiv, 137p. map. tabs. 10″.

Reading University. Department of Agricultural Economics. A simple system of economic analysis of a farm business; by C. H. Blagburn. Reading, 1954. 28p. fol. tabs. 9¾″. 5*s.* (Misc. Stud. 8.)

Richards, Denis & Saunders, Hilary St. George. Royal Air Force, 1939–1945, vols. 1–3. London, H.M.S.O., 1954. 3 vols. frontis., photos., maps. 8½″. 13*s.* 6*d.* each vol.

Riemer, Ruth, and Kiser, Clyde. Social and psychological factors affecting fertility. XXIII. Economic tension and social mobility in relation to fertility planning and size of planned family. *Milbank Mem. Fd. Quart.* (1954), **32**, 167–231. 1006–1068 p. 9″.

Rios, Sixtos. Introduccion a los metodos de la estadistica (Segunda parte.) Madrid, 1954. [viii] 193–434p. 8½″.

Rodgers, Winston & Hammersley, J. M. The consistency of stop-watch time-study practitioners. *Occup. Psychol.* (1954), 16p. 9¾″.

Rowson, R. B. Electricity supply: a statistical approach to some particular problems. *Proc. Instn. Elect. Engrs.* (1953), **99**, 151–172. (1954), **101**, 55–58. 11″.

Rushton, S. On the confluent hypergeometric function $M(\alpha, y, \acute{x})$. *Sankhya* (1954), **13**, 369–376. 11″.

Sequential procedures in the analysis of variance. *Proc. Int. Math. Congr. Amsterdam* (1954), **2**, 1. 9¾″.

Rushton, S. & Lang, E. D. Tables of the confluent hypergeometric function. *Sankhya* (1954), **13**, 377–411. 11¼″. [Duplicated sheets of values for $\gamma = 3$, $\gamma = 4$ which complete the computation 76, 1]. 11¼″.

Russell, Sir E. John. World population and world food supplies. London, Allen and Unwin, 1954. 513p. 9¼″. 30*s.*

Sanderson, Fred. H. Methods of crop forecasting. Cambridge, Mass., Harvard Univ. Press, 1954. (London, Geoffrey Cumberlege.) xv, 259p. 8¼″. 40*s.*

Savage, Leonard, J. The foundations of statistics. New York, Wiley, 1954 (London, Chapman & Hall.) xv, 294p. 9″. 48*s.*

Sayers, R. R. Modern banking; 3rd. ed. Oxford, Clarendon Press, 1953. xii, 337p. 8½″. 17*s.* 6*d.*

Spicer, C. C. The generation method of analysis applied to mortality from respiratory tuberculosis. *J. Hyg.* (1954), **52**, 361–368. 10″.

Thomas, Edgar. Management in farming. Newton Abbot, Devon, Seale-Hayne Agricultural College. vi, 52p. 8½″. 4*s.*

Thornton, John L. & Tully R. I. J. Scientific books, libraries and collectors: a study of bibliography and the book trade in relation to science. London, Library Association, 1954. x, 288 p. plates. 8½″. 24*s.*

Tostlebe, Alvin S. The growth of physical capital in agriculture, 1870–1950: a report of the National Bureau of Economic Research ... in co-operation with the Bureau of Agricultural Economics, United States Department of Agriculture. New York, N.B.E.R., 1954. xii, 92p. map. 9″. $1.25. (Stud. in Capital Formation and Financing. Occ. Papr. 44.)

Triffin, Robert. Monopolistic competition and general equilibrium theory. Cambridge, Mass. Harvard Univ. Press, 1949. (London, Cumberlege.) xii, 195p. 8½″. 24*s.* (Harvard Econ. Stud. 67.)

Ulmer, Melville, J. Trends and cycles in capital formation by United States railroads, 1870–1950. New York, National Bureau of Economic Research, 1954. [x], 70p. 9″. $1.50. (N.B.E.R. Stud. in Capital Formation and Financing. Occ. Papr. 43.)

Vajda, S. Einige statistische Modelle zur Analyse von Fussballresulten. *Statist. Vierteljahresschrift* (1954), 7, 26–37. 9″.

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Vinci, Felice. L'insegnamento universitario dell'economica e le sue nuove esigenze; [by] Felice Vinci *and* Gli effetti della svalutazione monetaria inglese del 1931; [by] Giancarlo Carlucci. Milano, 1954. 79p. 9¼″. (Università degli Studi di Milano Instituto di Scienzi Economiche e Statistiche. Quaderni 19 & 20.)

Vos, J. W. E. Een productiviteitsindex voor de akkerbouw; Index numbers of productivity in agriculture. *Lanbouwkundig Tijdschrift* (1954), **66**, 451–458. 9½″.

Richtlijnen voor de berekning van productie-indices. *Statistica* (1953), **7**, 127–140. 9½″.

Williams, I. G. *and others.* Carcinoma of the female breast: conservative and radical surgery. *Brit. Med. J.* (1953), **2**, p. 787. 27p. 8½.

Williams, J. D. The compleat strategyst, being a primer on the theory of games of strategy; with pictorial illustrations by Charles Satterfield. New York & London, McGraw-Hill, 1954. xiii, [3], 234p. illus. 9″. 38*s.*

Wishart, John & Metakides, Theocharis. Orthogonal polynomial fitting. *Biometrika* (1953), **40**, 361–369. 10¾″.

Yanakeiv, Rumen D. The principle of proportions between the production elements: Part I. "The law of diminishing returns" in the theories of the bourgeois economists, including the classical school. Annuaire de l'Université de Sofia Faculté des Sciences Économiques et Sociales II. 1948–1947. 73p. 9½″. [Text in Bulgarian.]

[Statistical problems in measuring labour productivity in the socialistic Industry.]. Annuaire de l'Université de Sofia, Faculté des Sciences Economiques et Sociales III, 1949–1950. 77p. [Text in Bulgarian.]

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BANK OF ENGLAND

Pursuant to the Act 7th and 8th Victoria, cap. 32 (1844)

(000's omitted)

1	2	3	4	5	6	7	8
		Issue Department				Collateral Columns	
Liabilities	Dates (Wednesdays)	Assets				Notes in Hands of Public	Minimum Discount Rate
Notes Issued		Govt. Dept. (£11,015) and Govt. Securities	Other Securities	Gold Coin and Bullion	Silver Coin*		
£		£	£	£	£	£	
1,625,357	Jan. 6	1,621,727	759	357	2,514	1,591,785	3½%
1,600,357	,, 13	1,596,729	759	357	2,512	1,563,169	
1,600,357	,, 20	1,596,769	718	357	2,513	1,543,210	
1,575,357	,, 27	1,571,739	747	357	2,514	1,535,185	
1,575,357	Feb 3	1,571,692	794	357	2,514	1,538,553	
1,575,357	,, 10	1,571,757	731	357	2,512	1,543,431	
1,575,357	,, 17	1,571,775	711	357	2,514	1,545,569	
1,575,357	,, 24	1,571,880	706	357	2,514	1,547,888	
1,575,357	Mar. 3	1,571,730	755	357	2,515	1,555,901	
1,575,357	,, 10	1,571,743	742	357	2,515	1,561,769	
1,625,357	,, 17	1,621,729	756	357	2,515	1,562,664	
1,625,357	,, 24	1,621,776	711	357	2,513	1,565,756	
1,625,357	,, 31	1,621,696	794	357	2,510	1,576,906	
1,625,358	Apr. 7	1,621,764	721	358	2,515	1,592,178	
	,, 14					1,609,014	
1,625,358	,, 21	1,621,693	792	358	2,515	1,615,116	
1,625,358	,, 28	1,621,696	794	358	2,510	1,612,557	
1,625,358	May 5	1,621,773	715	358	2,512	1,613,340	
1,625,358	,, 12	1,621,786	703	358	2,511	1,612,905	3
1,625,358	,, 19	1,621,773	713	358	2,514	1,609,768	
1,625,358	,, 26	1,621,713	776	358	2,511	1,613,420	
1,675,358	June 2	1,671,721	768	358	2,511	1,624,694	
1,675,358	,, 9	1,671,264	723	358	3,013	1,637,150	
1,675,358	,, 16	1,671,258	729	358	3,013	1,640,712	
1,675,358	,, 23	1,671,233	752	358	3,015	1,641,509	
1,675,358	,, 30	1,671,285	701	358	3,014	1,647,428	
1,675,358	July 7	1,671,189	797	358	3,014	1,661,664	
1,725,358	,, 14	1,721,232	756	358	3,012	1,675,996	
1,725,358	,, 21	1,721,227	761	358	3,012	1,701,273	
1,750,358	,, 28	1,746,280	706	358	3,014	1,715,829	
1,750,358	Aug. 4	1,746,280	706	358	3,014	1,716,918	
1,750,358	,, 11	1,746,269	720	358	3,011	1,695,486	
1,700,358	,, 18	1,696,207	782	358	3,011	1,670,527	
1,700,359	,, 25	1,696,237	751	359	3,012	1,653,968	
1,675,359	Sept. 1	1,671,232	756	359	3,012	1,649,903	
1,675,360	,, 8	1,671,195	792	360	3,013	1,647,727	
1,675,360	,, 15	1,671,235	751	360	3,014	1,642,629	
1,675,361	,, 22	1,671,221	766	361	3,013	1,638,027	
1,675,361	,, 29	1,671,188	798	361	3,014	1,635,381	
1,675,361	Oct. 6	1,671,232	757	361	3,011	1,639,441	
1,675,361	,, 13	1,671,221	768	361	3,011	1,637,887	
1,675,361	,, 20	1,671,251	738	361	3,011	1,636,073	
1,675,361	,, 27	1,671,266	722	361	3,012	1,635,947	
1,675,361	Nov. 3	1,671,247	741	361	3,012	1,643,646	
1,675,361	,, 10	1,671,196	790	361	3,014	1,647,671	
1,675,361	,, 17	1,671,189	797	361	3,014	1,648,175	
1,675,361	,, 24	1,671,289	700	361	3,011	1,651,851	
1,725,361	Dec. 1	1,721,253	732	362	3,014	1,669,249	
1,725,361	,, 8	1,721,206	782	361	3,012	1,703,679	
1,775,362	,, 15	1,771,213	772	362	3,015	1,742,028	
1,775,362	,, 22	1,771,257	733	362	3,010	1,758,688	
1,775,362	,, 29	1,771,214	771	362	3,015	1,751,708	

* Coin other than Gold Coin.

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WEEKLY RETURN

for Wednesday in each Week, during the year 1954

(000's omitted)

9	10	11	12	13	14	15	16	17	18
BANKING DEPARTMENT									
Liabilities				DATES (Wednesdays)	Assets				Totals of Liabilities and Assets
Capital (£14,553) and Rest	Public Deposits‡	Bankers' Deposits	Other Deposits		Govt. Securities	Discounts and Advances	Other Securities	Reserve (Notes and Coin)	
£	£	£	£		£	£	£	£	£
18,204	18,730	287,611	70,172	Jan. 6	333,321	9,783	15,638	35,975	394,717
18,218	27,147	271,538	71,186	,, 13	323,116	9,683	15,705	39,585	388,089
18,239	20,765	283,967	69,323	,, 20	295,626	20,418	16,717	59,533	392,294
18,289	23,211	278,648	68,053	,, 27	303,687	15,433	26,512	42,569	388,201
18,289	18,628	284,424	67,809	Feb. 3	299,764	18,298	31,896	39,192	389,150
18,354	20,669	286,839	64,968	,, 10	315,589	18,338	22,584	34,319	390,830
18,394	18,041	280,987	64,139	,, 17	317,730	10,308	21,306	32,217	381,561
18,441	15,652	284,025	65,910	,, 24	323,349	14,028	16,763	29,888	384,028
18,470	26,817	276,577	64,976	Mar. 3	327,530	12,537	24,909	21,864	386,840
18,488	21,633	277,408	65,358	,, 10	333,520	15,630	17,712	16,025	382,887
18,492	12,782	292,655	66,034	,, 17	296,184	10,223	18,409	65,147	389,963
18,526	18,031	280,974	64,582	,, 24	293,799	7,493	18,576	62,244	382,113
18,552	31,603	262,701	72,871	,, 31	303,395	15,223	15,857	51,252	385,727
17,710	14,261	287,040	64,029	Apr. 7	319,454	13,623	13,970	35,993	383,040
	15,531	278,152	64,578	,, 14	334,974	7,868	14,065	19,697	
17,833	11,403	292,531	63,479	,, 21	347,904	10,533	13,866	12,943	385,246
17,839	18,314	289,261	67,145	,, 28	355,564	7,528	13,967	15,500	392,559
17,868	28,572	275,462	69,332	May 5	353,054	9,608	13,866	14,706	391,234
17,892	24,579	270,616	70,664	,, 12	346,179	8,388	14,050	15,134	383,751
17,927	24,049	267,425	68,624	,, 19	338,829	6,974	13,902	18,320	378,025
17,970	18,593	267,814	69,804	,, 26	338,664	6,959	13,863	14,695	374,181
18,007	15,034	280,769	70,135	June 2	301,174	15,449	13,893	53,429	383,945
18,047	19,792	279,263	67,440	,, 9	321,444	8,839	13,775	40,464	384,542
18,100	15,431	287,176	66,222	,, 16	326,759	9,429	13,856	36,894	386,929
18,142	15,640	283,458	67,235	,, 23	320,924	13,610	13,847	36,094	384,475
18,172	19,265	307,743	71,343	,, 30	360,924	11,745	13,668	30,186	416,523
18,225	27,101	273,963	66,889	July 7	349,389	7,200	13,636	15,953	386,178
18,233	23,629	287,694	67,121	,, 14	323,356	7,794	13,896	51,631	396,677
18,288	21,429	277,519	68,890	,, 21	337,096	8,809	13,878	26,348	386,126
18,308	25,066	269,084	71,295	,, 28	324,912	8,232	13,805	36,804	383,753
18,333	25,503	273,740	66,967	Aug. 4	329,351	5,767	13,722	35,703	384,543
18,354	15,423	270,849	63,225	,, 11	289,557	7,560	13,602	57,132	367,851
18,406	15,276	274,214	76,514	,, 18	333,492	5,015	13,770	32,133	384,410
18,434	16,286	267,213	63,849	,, 25	296,412	6,985	13,698	48,687	365,782
18,469	18,277	266,677	67,861	Sept. 1	319,522	9,475	14,550	27,737	371,284
18,489	19,826	265,484	66,346	,, 8	318,376	7,145	14,692	29,932	370,145
18,493	21,200	280,435	65,958	,, 15	321,601	14,675	14,783	35,027	386,086
18,522	16,023	280,313	67,074	,, 22	321,826	5,720	14,754	39,632	381,932
18,548	22,716	276,138	68,961	,, 29	322,656	6,469	14,964	42,274	386,363
17,704	27,418	275,992	65,491	Oct. 6	325,477	8,629	14,275	35,224	386,605
17,741	23,982	280,979	64,619	,, 13	331,151	1,944	14,443	39,783	387,321
17,770	15,809	294,672	66,980	,, 20	334,362	4,729	14,542	41,598	305,231
17,817	16,055	295,619	65,434	,, 27	336,496	2,052	14,648	41,729	394,925
17,845	18,467	290,565	64,316	Nov. 3	332,877	9,838	14,450	34,028	391,193
17,880	20,461	295,791	64,655	,, 10	346,496	7,628	14,645	30,018	398,787
17,923	21,700	293,767	65,860	,, 17	350,756	4,328	14,637	29,529	399,250
17,926	21,365	293,680	72,305	,, 24	360,107	4,510	14,794	25,865	405,276
17,991	24,843	292,474	64,921	Dec. 1	323,747	3,390	14,625	58,467	400,229
17,999	21,571	289,546	63,695	,, 8	347,877	5,985	14,906	24,043	392,811
18,044	21,407	289,460	67,206	,, 15	340,006	7,495	14,929	33,687	396,117
18,082	29,595	270,808	63,832	,, 22	339,662	8,890	14,741	19,024	382,317
18,136	25,057	276,090	66,275	,, 29	335,837	8,868	14,847	26,006	385,558

‡ Including Exchequer, Savings Banks, Commissioners of Nat. Debt., and Div. Accounts.

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Vol. 118.] [Part II

Journal of the Royal Statistical Society

SERIES A (GENERAL)

PART II, 1955.

Net Investment in Fixed Assets in the United Kingdom, 1938–1953

By Philip Redfern

[Read before the Royal Statistical Society, January 19th, 1955, the President, Lord Piercy, C.B.E., in the Chair]

Introduction

1. Since the war, there has been increasing recognition of the need for further study of the subject of investment in fixed capital—in particular the need for further statistical analysis. As a result a considerably greater amount of information on the country's gross investment in fixed assets (that is expenditure on additions to, and renewals of, buildings, vehicles and machinery) has been collected than was available before the war. This has enabled an assessment to be made of the gross amount of resources being devoted to investment in fixed assets in the country as a whole and in each industry. But the figures so far available have been lacking in one very important respect. There have been no satisfactory estimates to indicate how much of this gross investment expenditure has been required to make good the wearing out of previously-existing fixed assets; and how much has been left over to provide for *net* additions to the country's stock of fixed capital assets. Consequently it has not been possible to measure the net rate of growth of domestic capital and the relative rates of growth in each industry.

2. The aim of this paper is therefore to present such a division of the gross investment statistics, and to derive estimates of the rate of growth of domestic capital. I have taken as a starting point the official estimates of gross investment (or "gross domestic fixed capital formation") published in August, 1954 in the *Blue Book*, "National Income and Expenditure, 1946–1953"—which I subsequently refer to as the "*Blue Book*, 1954"—and have attempted to produce estimates of net investment, or "net domestic fixed capital formation", of comparable scope and with similar classifications. These estimates cover the years 1938, and 1948 to 1953. The calculations also yield tentative estimates of the gross replacement value of domestic fixed capital at three points of time—the end of the years 1938, 1947 and 1952, and corresponding estimates of the *net* value of domestic fixed capital (i.e. the gross replacement value written down to allow for accrued depreciation).*

Arrangement of the Paper

3. The first part of the paper (paragraphs 4 to 14) sets out the problem and indicates the general lines of the solution here adopted. There follows a discussion of some important problems, some theoretical and some practical, which arise in applying this solution (paragraphs 15 to 29). More detail on the scope of the estimates given in this paper and on the methods actually employed in the calculation appears in paragraphs 30 to 40. The main results are embodied in Tables 1 to 8, with some supplementary information in Tables 9 to 13, and some of the principal conclusions to be derived are mentioned in paragraphs 41 onwards.

* The methods adopted in this paper are similar to those employed by R. W. Goldsmith in the United States in his study "A Perpetual Inventory of National Wealth". (*Studies in Income and Wealth*, Vol. 14, published by the National Bureau of Economic Research, New York, 1951.)

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I. *The Problem and the Solution Proposed*

4. There is general agreement among economists that the national income should be measured after a deduction has been made from total output of goods and services to represent the capital resources "used up" in the process of production. The national income should thus be measured after deducting provision for maintaining capital intact, and a corresponding deduction should be made in measuring one element of final expenditure, namely fixed capital formation. I have no intention of adding in this paper to the considerable literature on the general principles of measuring capital consumption. It is, however, necessary to admit at once that there is probably no perfect statistical solution to the problem posed by the economists; there can only be approximations and arbitrary conventions. This paper attempts to express in figures one possible approach to a solution.

5. There are various ways in which capital consumption might in principle be measured. It might, for example, be assumed that an asset, if properly maintained, retained its full value until it was ultimately scrapped; capital consumption would then be represented simply by the assets going out of use and net investment would represent the difference between new assets installed and existing assets scrapped. This assumption clearly has an element of truth in it and it is in fact the basis of the accounting system wherein *renewals* of fixed assets are charged to operating account. But the method has major drawbacks. Firstly *net* investment would take no account of the ageing of an existing asset which was not scrapped. The assumption would thus ignore what has been described as the "two dimensional" nature of capital: the essence of a productive asset is that it continues to render services over a long period; its value is related not only to the service it renders in a given year, but also to the number of years over which it can be expected to remain productive. A second disadvantage of ignoring the ageing of assets is that it would imply a level of net profit and of national income fluctuating erratically according to the incidence of the scrapping of assets.

6. Alternatively, it might in theory be possible to find a measure of capital consumption based on the physical wear and tear of productive assets, together with some measure of rates of obsolescence. This might come closer to the economic significance of capital consumption. Some national income statisticians have attempted an approach to this by varying the level of depreciation in the national accounts in accordance with variations in the level of total output, the latter being taken to represent the intensity of usage of the asset. In our present state of knowledge there are inadequate data to apply these methods.

7. The solution in fact adopted in this paper is to accept the fundamental convention employed by accountants for estimating depreciation: this is that use of an asset may be regarded as being spread in some arbitrary way over a predetermined life. There is, of course, more than one way of spreading the use of an asset over time. The method adopted here is the "straight line" method under which the asset is assumed to depreciate by a constant amount each year (one-tenth of its cost if the asset is assumed to last 10 years). The most common alternative is the "reducing balance" system wherein the successive annual allowances are (except the last of the series) in the form of a geometric progression; the depreciation allowances get smaller as the age of the asset increases, being a constant *proportion* of the written down value at the beginning of each year. This is the basis of the method used in estimating depreciation allowances for tax purposes in the United Kingdom. These two alternative methods of spreading the use of an asset over time can give rise to considerable differences in the calculated depreciation. The choice between them must involve an element of arbitrariness, but I have chosen the straight line rule on the grounds that in a great number of cases the productive services rendered by an asset are likely to be more nearly constant over time than to reduce exponentially.

8. Although the fundamental accounting convention of spreading depreciation over a predetermined life (using the "straight line" method) is accepted here, the way in which it is applied has one major difference. The commercial accountant normally depreciates the original cost. It is unnecessary to enter here into the current controversy over the appropriateness, for commercial accountancy, of depreciating on the basis of original cost. The categorical statement may simply be made that, for the measurement of the national income and of net investment, depreciation at original cost is irrelevant. What one is seeking to determine is a measure of the use of capital expressed in the same prices as the other transactions recorded in the national accounts. For estimating the national income, product and expenditure in current prices, the object is to estimate

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capital consumption in the current prices of each year. For estimating the national product and expenditure in terms of constant prices of the year X, the object is to estimate capital consumption in each year at the prices of year X.

Limitations and Qualifications

9. Before describing the methods and the results in more detail three warnings should be given. Firstly net investment is derived here from the change in the written-down value of assets, after correction for price changes. It cannot be too strongly emphasised that this will normally differ from a measure of changes in productive capacity, or in the "quantity" of assets in place. Thus the estimates of net investment here given take account not only of changes in the quantity of assets installed but also of changes in their unexpired lives—a "two dimensional" concept; whereas measures of productive capacity or quantity of assets in place are essentially one-dimensional. Moreover the estimates of net value of assets here given will normally differ from a measure of their income-earning capacity or their second-hand market value (in cases where a second-hand market exists). In conditions of stability second-hand market values must be related to the written-down replacement cost (which is the measure of net value here employed)*, but in the short run the two valuations may differ substantially.

10. In the second place it must be recognized that the nature of technical change makes it impossible to express in any accurate way the concept of "maintaining capital intact." A worn-out machine is rarely replaced by a precisely identical machine; it may be replaced by a more efficient machine, or, because some new process has been invented, the worn-out machine may not be replaced at all. The problem is to assess the quantitative relationship between new machines currently being installed and machines installed in the past; if a new machine embodies the same quantity of factors of production as an old machine, but has an output 50 per cent. greater than the old machine, is the new machine to be regarded as the equivalent of 1 old machine or 1·5 old machines?

11. This problem resolves itself into constructing a price index for each type of capital good: an attempt might be made to measure the changes in the price of goods embodying a constant quantity of factors of production or changes in the price of goods of constant productive capacity. Without embarking on a discussion of which approach is more appropriate, it is sufficient to state here that the choice is largely dictated by the available data. The price indices here employed tend to be of the former type, that is to measure the prices of goods embodying a constant quantity of factors of production. For instance the price index for plant and machinery has been derived mainly from changes in the average value per ton of particular descriptions of machinery as given in the Census of Production and export statistics. In consequence the figures of net investment appearing in this paper tend to omit increases in productive resources arising not from the increase in the number of assets in use but from an increase in their efficiency.

12. In the third place, even if the conventions and definitions used here be accepted, there is room for substantial errors in measurement arising in particular from three causes :

(i) The calculations involve the formulation of price indices for vehicles, machinery and buildings extending over long periods, and the data available for doing this are very incomplete. Some of the difficulties in constructing price indices for products whose character is continually changing have already been discussed in the preceding paragraph.

(ii) The calculations depend heavily on the assumed lengths of life of assets—though in fact, as will be shown later, the difference made by an error in the assumed lives is not so great as might be expected.

(iii) It will be seen that the method also involves the construction of estimates of gross investment in the past—sometimes the very distant past. No accurate figures can now be compiled of levels of investment for years much earlier than 1948.

Illustrative Example of the Calculation

13. It is perhaps worth while at this stage to set out an example of the way capital consumption (depreciation), net capital formation (net investment) and the net value of capital assets have been calculated. This is shown in the following table and is illustrated by a graph. In the example the life of each asset has been taken to be the same (viz. 10 years).

* Second-hand market values may not, of course, fall linearly with time.

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£ *at Constant Prices*

Year	*Gross Capital Formation* (1)	*Gross Value of Assets Discarded* (2)	*Change in Gross Stock of Capital* (3)	*Gross Stock of Capital (end of year)* (4)	*Capital Consumption* (5)	*Net Capital Formation* (6)	*Net Stock of Capital (end of year)* (7)
1	10	—	+10	10	1	+9	9
2	10	—	+10	20	2	+8	17
3	10	—	+10	30	3	+7	24
4	10	—	+10	40	4	+6	30
5	10	—	+10	50	5	+5	35
6	10	—	+10	60	6	+4	39
7	—	—	—	60	6	−6	33
8	—	—	—	60	6	−6	27
9	—	—	—	60	6	−6	21
10	—	—	—	60	6	−6	15
11	10	10	—	60	6	+4	19
12	10	10	—	60	6	+4	23
13	10	10	—	60	6	+4	27
14	10	10	—	60	6	+4	31
15	10	10	—	60	6	+4	35
16	10	10	—	60	6	+4	39
17	—	—	—	60	6	−6	33
18	—	—	—	60	6	−6	27
19	—	—	—	60	6	−6	21
20	—	—	—	60	6	−6	15
21	—	10	−10	50	5	−5	10
22	—	10	−10	40	4	−4	6
23	—	10	−10	30	3	−3	3
24	—	10	−10	20	2	−2	1
25	—	10	−10	10	1	−1	—
26	—	10	−10	—	—	—	—

Col. (2) is similar to col. (1) but is lagged by 10 years (the assumed length of life of the fixed assets in question).
Col. (3) = col. (1) *less* col. (2).
Col. (4) = col. (3) cumulated.
Col. (5) = 0·1 *times* sum of col. (1) in the 10-year period ended in the current year.
= 0·1 *times* col. (4).
Col. (6) = col. (1) *less* col. (5).
Col. (7) = col. (6) cumulated.
= weighted sum of col. (1) in the 10-year period ended in the current year, the respective weights being 0 (for the earliest year), 0·1, 0·2, . . . , 0·8 and 0·9 (for the current year).

The example brings out the distinction between the gross value of assets discarded and capital consumption; the corresponding difference between the change in the gross stock of capital and net capital formation; and the consequent difference between the gross stock of capital and the net stock of capital.

14. The example also shows that positive or negative net capital formation may occur without any change in the quantity of assets in use. Thus net investment is not necessarily a guide to the changes in the size or capacity of any industry. Positive net investment may imply an increase in the quantity of assets in use or capacity, or it may be the consequence of a large renewals programme (as at the end of the war, when it became necessary to replace worn-out equipment) without any current (or prospective) increase in capacity; in other words, net investment represents either an increase in capacity or an increase in the average future life of the assets in use. Similarly, negative net investment may mean a reduction in capacity or it may mean a decrease in the average future life of the assets in use.

II. *Problems which arise in Applying the Proposed Solution*

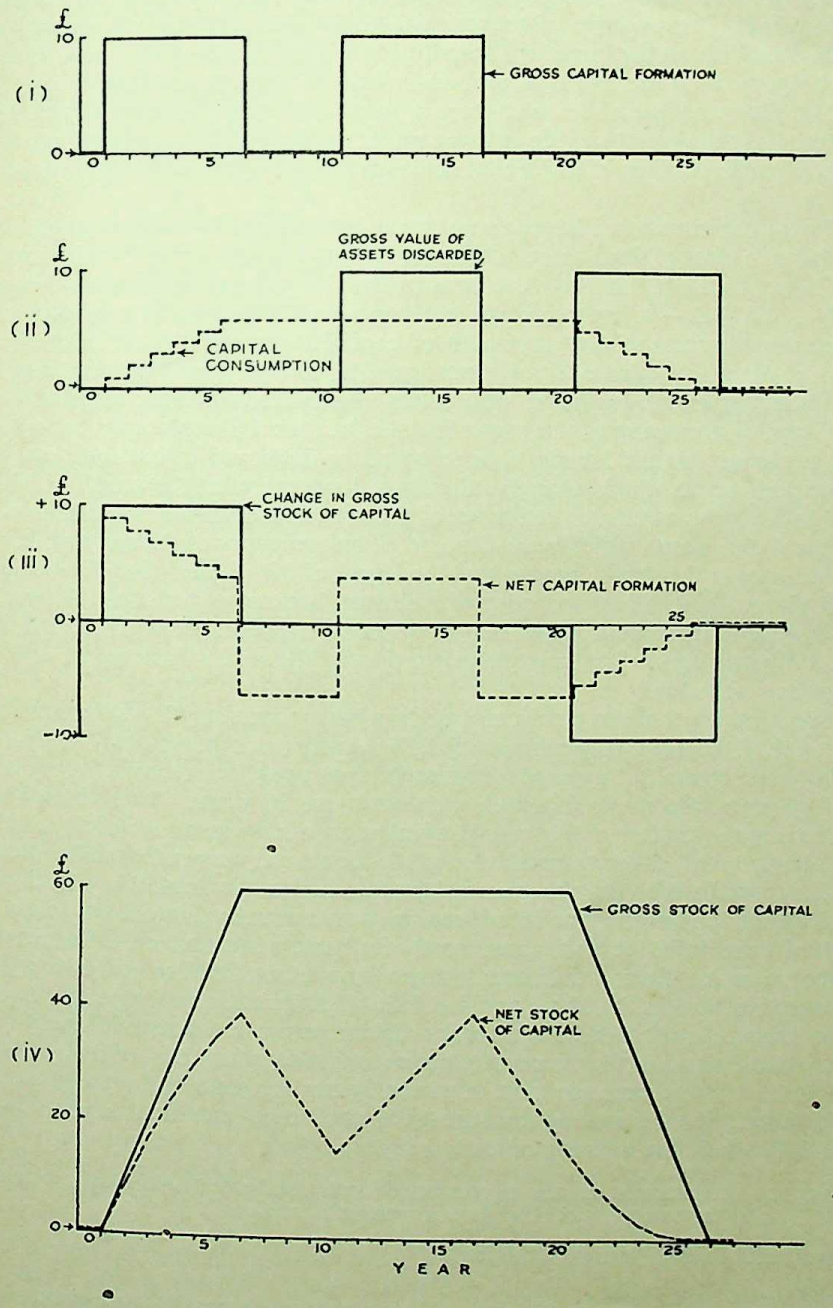
Length of Life of Assets

15. The principal problem in applying the method just described arises from lack of knowledge about the length of life of the assets being depreciated. Firstly there is lack of knowledge as to how long assets now in existence will last in the future. A machine existing today may last twenty years, it may be destroyed by fire tomorrow or it may obsolesce and be superseded next year,

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DIAGRAM ILLUSTRATING TABLE



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None can tell. The owner of the asset is therefore obliged to estimate its life as best he can and depreciate it accordingly. If the asset is, in the outcome, scrapped before the end of its estimated life he will have to charge its unexpired value (i.e. its net capital value) to depreciation; on the other hand, if its actual life exceeds the estimated life he may, during the last years of the asset's life, be employing an asset whose net capital value has been written down to nil and for which no further depreciation provision is necessary. In either event the owner of the asset is unlikely to wish to alter retrospectively the depreciation provisions for each year back to the year of installation. But quite apart from lack of knowledge of the unpredictable future, anyone who attempts to compile estimates of depreciation on the lines here described is in practice faced with lack of data which in theory could be gathered if enough time and effort were devoted to their collection. Thus, with a few exceptions, I have not been able to collect any information about the age distribution of assets now extant, nor about the lengths of life of those assets which have already been scrapped; furthermore it is only for a few classes of assets that statistics are available of the total quantity of assets in use.

16. Faced with this situation I have in most cases been forced to make assumptions about the length of life of each class of fixed asset. An asset installed in year X has been assumed to have a life of (say) L years and it has therefore been written off in equal instalments over the years X, $X+1, X+2, \ldots, X+L-1$, irrespective of whether or not the actual life exceeded or fell short of L years.* And my estimates of the gross value of capital at any point of time have been deduced from statistics of the gross value of fixed assets installed in each preceding year coupled with the assumptions about the length of life of such assets. In consequence the calculated estimates of gross value of capital appearing in this paper include (at their full replacement cost) assets which in reality are no longer extant, having been scrapped or destroyed before their assumed life has expired, and exclude assets which, though still extant, have exceeded the length of life assumed in this paper. Similarly the calculated estimates of the *net* value of capital include, at their written-down replacement cost, assets which were disposed of before expiry of the assumed length of life.

17. The estimates in this paper assume that the length of life of each class of asset has remained constant throughout the whole period covered, whereas, because of technical changes, changes in intensity of usage or other reasons, assets may now have longer (or shorter) lives than similar assets did 25, 50 or 100 years ago. The example in paragraph 72 does in fact suggest that average lives of some assets have changed.

18. It is worth noting that the errors in the assumption about length of life usually have a less serious effect on the figures of changes in net capital (i.e. figures of net investment) than on the figures of changes in gross capital. Suppose, for example, that a particular class of asset is assumed to have a life of 40 years whereas in fact each such asset lasts 30 years. Then the calculated figure for the increase in gross capital in 1954 would equal value of new assets installed in 1954 *less* gross value (at replacement cost) of assets installed in 1914; the correct answer should have been the value of new assets installed in 1954 *less* the gross value of assets installed in 1924. On the other hand, the calculated figure for the increase in *net* capital would equal value of new assets installed in 1954 *less* $\frac{1}{40}$th of gross value (at replacement cost) of all assets installed in the 40-year period 1915–1954 inclusive; the correct figure would equal value of new assets installed in 1954 *less* $\frac{1}{30}$th of gross value of all assets installed in the 30-year period 1925–1954 inclusive.† Although the year to year changes in the figures of net capital are less susceptible to errors in the assumed lengths of life than are the year to year changes in the figures of gross capital, the general *level* of both series is affected to the same extent. In the example mentioned the figures for gross and net capital employed at the end of 1954 would (on the assumption that the level of investment had remained constant over the period 1915–1954) each represent $\frac{4}{3}$ of the true figures.

* Exceptions to this statement are the treatment of assets totally destroyed in the war of 1939–1945 (see paragraph 29) and the treatment of ships (see Appendix B, section 9).

† If the investment in each year is of the form

$$i_t = \alpha + \beta t + \varepsilon_t$$

where α and β are constants, t denotes the year and ε_t is a random element with mean zero and standard deviation σ, an error of λ years in the assumed length of life introduces the following errors:

Error in the estimate of the increase during any year in gross value of capital $= \beta\lambda + \zeta$.

Error in the estimate of the increase during the year in net value of capital $= \frac{1}{2}\beta\lambda + \eta$

where ζ and η have distributions with zero means and variances $2\sigma^2$ and $\lambda\sigma^2/L(L+\lambda)$ respectively, and L is the true length of life.

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19. Some actual figures illustrating these points are given below.

Net Investment in Plant and Machinery for Manufacturing and Distribution, etc.

	£ *Million at Constant* 1948 *Prices*	
	Assuming Lengths of Life in Range 14 *to* 45 *Years*[1] (A)	*Assuming Lengths of Life Exactly* ¾ *of Lengths Assumed in Column* (A) (B)
Net fixed capital formation:		
1938	88	87
1948	114	106
1949	131	123
1950	160	150
1951	180	170
1952	143	134
Net fixed capital:		
At end of 1938	2,127	1,670
„ „ „ 1947	2,234	1,687
„ „ „ 1952	2,962	2,370

[1] The estimates shown in this column are those appearing in Table 9.

These figures confirm that the estimates of net capital employed at any point of time will be in error by a percentage approximately equal to the percentage error in the assumed lengths of life, but that the estimates of net investment are in error to a lesser extent.

Obsolescence

20. A general problem encountered in measuring depreciation is what allowance to make for obsolescence. Should the assumed lives be shortened to allow for the fact that, on the basis of past experience, some assets will be superseded before they are physically worn out? As a statement of principle, I accept that the lives should be so shortened. But in practice the lives assumed in this paper are (for most classes of asset) the lives assumed by the tax authorities or by public authorities in their own accounts; and the extent to which these lives take account of obsolescence is not in every case precisely known.

Civil Engineering Works

21. The problem of obsolescence becomes particularly acute in the case of some classes of civil engineering works which, it can be argued, would last for ever if properly maintained. Examples are reservoirs, embankments, tunnels, canals and road beds; the foundations of factories and other buildings might also come into this category. Arguments can be advanced that such fixed assets ought not to be depreciated during their life and that, if ultimately these assets are superseded, either the whole of their value should be written off at the date of scrapping or alternatively their scrapping should be regarded as a capital loss which would not be deducted in arriving at either national income or net investment.

22. The first of these two methods of treatment has already been rejected for reasons explained in paragraph 5. And I have not adopted the second of the alternatives. Instead all the classes of asset in question have, in this paper, been written off over a long—but arbitrary—period of years. My reasons for following this treatment are threefold. Firstly a substantial proportion of these assets do in fact obsolesce even if they do not wear out, and I have here adopted the general principle that annual capital consumption should include allowance for obsolescence. Thus there are many examples of almost forgotten ports round our coastline, of abandoned canals and tram tracks, even of aerodromes which no longer meet the needs for which they were first built. Even if to-day we cannot foresee when a particular civil engineering work will be superseded, that is no reason why it should not be depreciated over a long period of years.

23. The second reason for writing off all civil engineering works is that I am not altogether convinced by the argument that if the assets were properly maintained and they did not obsolesce

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they would in fact last indefinitely. Thus sea walls can and do crumble even if properly maintained; and costs of maintenance of (say) a tunnel may become so great that it is more economic to build a new one than to keep the existing one in use.

24. Thirdly, the available statistics in practice rarely separate out those classes of civil engineering work which might be excluded from the depreciation calculation from all other classes of civil engineering and building work. Thus the statistics of expenditure on railway construction do not distinguish between the embankment which could perhaps last indefinitely and the station building which certainly will not do so.

25. It must be admitted however that the lengths of life assumed in this paper for some classes of civil engineering works, such as roads, are extremely arbitrary, and that in some cases choice of a different length of life would have led to somewhat different results. Moreover if the view be taken that no depreciation should be allowed for (say) road foundations, then net investment in this class of asset has been understated, or (as it is in this case) the extent of net disinvestment has been overstated.

Excess Maintenance

26. The value of any asset depends not only on its replacement cost and its age, but also on how well it has been maintained. This could be taken account of in our system of capital accounting if we could adjust our capital consumption estimates to allow for over- or under-maintenance. We can suppose that a given asset such as a house requires a fixed sum spending annually on repairs and maintenance (prices being assumed constant) in order that the asset shall yield the full services required of it for the whole of its expected life. If actual repairs and maintenance in any year exceed this fixed sum, it can be assumed that the net value of the asset is thereby increased by the amount of the excess, either because the future life of the asset has been increased or because the services expected to be rendered by the asset have been enhanced (this would be the case if liabilities for repairs in succeeding years were reduced). We should therefore reduce capital consumption by the amount of the excess repairs; the total charges to operating account for the year in question (viz. capital consumption *plus* actual repairs and maintenance carried out) would be unaffected by the "excess maintenance". Thus excess maintenance, though excluded from gross investment, would nevertheless contribute, as it should do, to net investment. In a similar manner, capital consumption would be increased by the amount of any under-maintenance, and net investment and the net value of assets at the end of the year in question would thereby be reduced.

27. Whilst I recognize that something on these lines should be done if the figures of net investment are to have most meaning,* the depreciation figures given in this paper do not in practice make any allowance for excess maintenance. This is because the data on actual repairs and maintenance carried out and on what a "normal" repair provision would be are totally inadequate for the majority of classes of fixed assets. This must be borne in mind in interpreting the figures given later in the paper. In particular the figures for net value of assets at the end of 1947 have not been reduced on account of *repairable* war damage or wartime arrears of normal maintenance, although the *complete* destruction of assets due to air raids in the 1939–1945 war has been taken into account (see paragraph 29). Moreover war damage repair work has for national income purposes been treated as a current expense, and so excluded from gross investment; reinstatement of completely destroyed assets has been included in gross investment. Consequently the figures of net investment for the period 1948–1953 do not include anything for war damage repair work carried out in that period, but do take account of complete rebuilding of assets destroyed.

Destruction by Fire and War, etc.

28. I have not found it practicable to make any *special* allowances for complete destruction by fire or "Act of God", except in the case of shipping losses and of destruction by air raids in the war of 1939–1945. Except in these special cases, each asset has been written off over its assumed life irrespective of whether in fact it was prematurely destroyed. But the capital consumption allowances are not on this account underestimated, at least so far as the average over a period of years is concerned. The assumed lengths of life may in fact be regarded as making some allowance for fire and other risks by being slightly shorter than they would otherwise be.

* The possibility that the treatment set out in paragraph 26 would eventually be adopted was mentioned in the *National Income Blue Book* of 1953 (p. 94, penultimate paragraph).

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29. So far as destruction in the 1939–1945 war is concerned, all fixed assets totally destroyed have been completely eliminated from the post-war gross and net value series. But the data are inadequate to make more than a rough adjustment for this.

III. *Scope of the Estimates*

30. The estimates given in this paper of net investment and depreciation and of the value of gross capital and net capital have (with the exceptions noted in paragraphs 31 and 32 below) the same scope as the estimates of gross fixed capital formation in the *National Income Blue Book* of 1954. It follows that fixed capital assets here exclude consumers' durable goods, such as motor cars and furniture owned by persons, but houses and buildings owned by persons are included. Non-revenue producing assets owned by public authorities, such as roads and schools are also included, but, as in the *Blue Book*, buildings and equipment for the Armed Services are excluded from the scope of the fixed capital estimates.* The estimates do not take account of intangible assets such as financial assets, patents and goodwill, nor of stocks of materials and finished products and work-in-progress.†

31. The estimates given here exclude site values (i.e. land), which do not of course depreciate (in the sense in which the word "depreciate" is used in this paper). Except in Tables 1 and 10 the estimates also exclude expenditure on legal fees and stamp duties incurred when land and property are purchased, though such expenditure is treated as gross fixed capital formation in the *Blue Book*; in Tables 1 and 10, however, expenditure on legal fees and stamp duties has been included in total gross investment, but in deriving totals of net investment in these tables this class of expenditure has been regarded as though it were wholly written off in the year in which it was incurred. No allowance has here been made for the depletion of natural resources such as coal.

32. Because of the absence of suitable data, or because the extraction of suitable material required more time and detailed study than I have so far been able to give it, I have, unfortunately, been obliged to omit from my detailed calculations certain classes of fixed capital assets. These assets are excluded from all the tables in this paper except Tables 1 and 10. The principal omissions are farm buildings, coal industry buildings and mine workings and most of the Central Government's non-trading assets (such as hospitals, Government offices and research establishments).‡ A full list of the omitted classes of assets is given at the end of Appendix B. The omitted classes contribute however only about 6 per cent. of gross domestic fixed capital formation in the years 1948 to 1953, and their omission cannot seriously affect the general results obtained. In Tables 1 and 10, very rough estimates have been included for these assets for the sake of completeness.

IV. *The Methods Employed*

33. The process of estimation used here involves three operations :

(i) Estimates are made of gross fixed capital formation in each past year for each class of asset separately distinguished. To enable net investment and net capital to be calculated for the period 1938–1953, each series has been taken back L years before 1938, where L is the length of life of the asset in question.

(ii) Price indices are built up for the principal classes of assets. By applying these to the gross fixed capital formation series, estimates of gross fixed capital formation at constant prices (of the year 1948) are derived.

(iii) Assumptions, supported by varying amounts of evidence, are made about the lengths of life of each class of asset. By writing off the gross investment in each class of asset over the assumed life, estimates of depreciation, net fixed capital formation, and the gross and net value of capital are derived, in terms of constant prices of the year 1948; the table in paragraph 13 illustrates the method of computation. These estimates of depreciation, net fixed capital formation, etc., can then be converted to the prices of other years, if required, by use of the price indices previously referred to.

34. So far as the data have permitted, the estimates have been worked out separately for each industry (e.g. electricity, railways, housing) and within each such industry by type of asset (buildings,

* Married quarters for the Armed Services are an exception and are treated as fixed capital assets.
† Livestock and growing timber are included under stocks and work-in-progress, and so excluded from the estimates given in this paper.
‡ Trunk roads and houses owned by the Central Government are however covered by the estimates.

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plant, road goods vehicles, etc.). Unfortunately (with a few exceptions, such as shipping, road passenger transport and agriculture) I have been unable to show separately the figures for individual private industries. This is because the pre-war estimates of gross fixed capital formation outside the "public utility" field must necessarily be derived from production data, and no division of the output data between the different "capital-consuming" private industries is possible. The result is that the tables appearing later in this paper show as a single industry group a rather heterogeneous collection of industries described as "Manufacturing and distribution, etc.", which is analysed only by type of asset (i.e. between vehicles, plant, industrial buildings and commercial buildings). If the statistics of gross investment in 1948–1953 can be taken as a guide, over 80 per cent. of the plant and 95 per cent. of the industrial buildings in this group are employed in manufacturing industry; it is possible, however, that the proportions applying in the period 1948–1953 may differ from the proportions in earlier periods (e.g. because of post-war building controls).

The Estimates of Gross Fixed Capital Formation

35. I will comment briefly on the three operations referred to in paragraph 33, taking first the estimation of gross fixed capital formation. For the years 1948–1953, the figures published in the *National Income Blue Book* of 1954 have been used. For earlier years, I considered the possibility of making use of estimates made by earlier investigators. I concluded, however, that it was necessary to re-work my own estimates from the basic data, because existing estimates of gross investment were not in the necessary detail for my purposes and most of them did not cover a sufficiently wide span of years. Furthermore, if estimates made by earlier investigators had been used, it would have been necessary to make adjustments to the figures to align the definitions (e.g. as regards the treatment of repairs) with those employed here. I have, however, made extensive use of the investment estimates for 1870–1914 given by Professor A. K. Cairncross in *Home and Foreign Investment*, 1870–1913 (1953).

36. Appendix B describes in some detail the sources used for the estimates of gross fixed capital formation for years before 1948. Where possible I have made use of expenditure data—for example, for electricity, railways, the Post Office and local authority services. Series on numbers of road vehicle registrations, on tonnage of ships launched and on number of houses built for private owners have been employed to cover these classes of assets. For the rest, that is for agricultural machinery, coal mining machinery, and machinery and buildings for manufacturing and distribution, the principal source used has been production statistics from the *Census of Production* (*plus* imports and *less* exports); the figures for censual years have been interpolated and extrapolated on the basis of employment in the engineering industries, building plans passed in a sample of towns, and the like.

37. The further one goes back into history the more uncertain the estimates of gross investment become, and I have been forced to hazard many guesses in preparing series running, in some cases, as far back as 1839. For the war years too, 1914–1919 and 1939–1945, the basic data are very fragmentary. In Tables 3, 4 and 9 are set out estimates of gross fixed investment (converted to constant 1948 prices) for the more recent years, to provide a background to the estimates of net investment. These estimates of gross fixed investment are not in any sense a definitive set of figures, as they were obtained primarily as a step towards calculating depreciation. Other investigators are at present engaged in estimating in some detail gross fixed capital formation between the wars.

Prices Indices

38. For few classes of capital assets are there any true price indices. For the important class of plant and machinery I have used figures of average value per ton extracted from the *Census of Production* or export statistics. This may well be the source of substantial error. For in the first place only a single price index has been employed to cover all classes of plant and machinery (but not vehicles), whereas it is probable that price indices for different classes of plant would, if available, be found to diverge considerably. In the second place much uncertainty must always surround price indices for such unstandardised products as plant and machinery. Some aspects of this problem have already been referred to in paragraph 11. The special weakness of these price indices is that changes in quality cannot be fully reflected in them. If the indices overstate the actual rise in the price of an unchanging product (if, for example, most of the products priced have in fact increased in complexity and in efficiency), then the estimated rise in the replacement cost of plant

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has been correspondingly overstated, and net investment understated. With the information available, there is no way of measuring the extent of this error and no certainty about its direction.

39. The prices indices for different classes of asset are set out in Appendix A, where they are described in more detail.

The Lengths of Life Assumed

40. For plant and machinery employed in private industry, the assumed lengths of life are those implicit in the rates of depreciation allowed for taxation purposes.* For road vehicles a figure of 10 years has been taken, which again is implicit in the Inland Revenue depreciation allowances. For industrial buildings the Inland Revenue figure of 50 years' life has been assumed. I have taken 75 years for "commercial" buildings such as offices and shops† and for buildings employed in public non-trading services (for example, schools); and 100 years for houses. For the principal "public utilities"—that is gas, electricity, railways and the Post Office—I have so far as practicable used the same lengths of life as the undertakings themselves employ in computing their accounting figures of depreciation; an exception is that the life of railways tracks, buildings and works has been taken as 100 years, there being no depreciation allowance for this class of asset in the railways' own accounts.‡ Fuller information on the lengths of life assumed for each industry is given in Appendix B.

V. *The Results*

41. From what I have already said it will be clear that the estimates here given of net investment and net value of capital cannot be regarded as precise, and the figures for gross value of capital employed are a good deal less reliable than those of net capital. Nevertheless I believe that the estimates do indicate broad orders of magnitude and so represent a step forward from the previously existing state of knowledge. I might add that the investigator who in 50 years' time sets out to perform the same sort of calculations as have been attempted in this paper should have available to him as a starting point a fairly reliable and detailed series for gross fixed investment going back 55 years, in contrast to the situation to-day with detailed statistics of fixed investment going back only some 5 years.

The Main Tables

42. The main results are set out in Tables 1 to 8. In Tables 1 and 2 the estimates are expressed in terms of the current prices of each year, whereas in the remaining tables (3 to 8) the estimates are all in terms of constant prices of the year 1948. Table 1 (current prices) and Table 5 (constant prices) show gross and net fixed capital formation in the years 1938 and 1948 to 1953, with an analysis between six main industry groups.§ Table 2 (current prices) and Table 6 (constant prices) give similar figures analysed this time by type of asset (plant and machinery, houses, other buildings and works, and six types of "vehicle"). Tables 3 and 4 present estimates of gross fixed capital formation at constant prices for the years 1924 to 1938 and 1948 to 1953. These two tables (which give respectively analyses by industry and by type of asset) are intended as a background to the net investment estimates. Estimates of the gross value and net value of capital at the end of the years 1938, 1947 and 1952, in each case expressed in terms of constant prices of the year 1948, appear in Table 7 (with an analysis by industry group) and Table 8 (with an analysis by type of asset).

43. The main Tables 1 to 8 do not give the full industry detail in terms of which the calculations were performed. As this may be of considerable interest in itself, and because it throws light on the results for the broader industry groups in the main tables, the full industry detail is set out in Table 9. But it may be that the figures there given are less reliable than the aggregates for broad industry groups in the main tables.

Conclusions

44. A detailed commentary on the conclusions to be drawn from the tables seems unnecessary, but it may be worth while mentioning some of the main features. Table 10 sets out total net fixed

* See the Inland Revenue's *Income Tax, Wear and Tear Allowances for Machinery or Plant: List of Percentage Rates* (1953).

† Cf. the report of the Millard Tucker Committee (Cmd. 8189, 1951), paragraph 204.

‡ It is worth noting however that the British Transport Commission accounts contain a provision for amortizing their long-term borrowing over a period of 90 years.

§ The industry classification is defined in Appendix B.

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TABLE 1

Gross and Net Fixed Capital Formation in Each Industry group. At Current prices

£ million

	Agriculture(1)	*Coal*(2), *Gas, Electricity and Water*	*Transport and Communication*(3)	*Manufacturing and Distribution, etc.*(3)	*Housing.*	*Public and Social Services*(4)	*Sub-total*	*Assets omitted from the Detailed Calculations*(5)	*Legal Fees, Stamp Duties, etc.*	*Total*
Gross fixed capital formation:										
1938	6	61	102	211	180	39	599	(40)	17	656
1948	58	156	182	479	342	43	1,260	90	46	1,396
1949	52	196	204	550	332	63	1,397	98	49	1,544
1950	51	214	214	640	331	76	1,526	105	51	1,682
1951	56	237	212	726	372	97	1,700	112	54	1,866
1952	54	265	220	755	489	115	1,898	123	45	2,066
1953	51	299	277	776	631	127	2,161	133	39	2,333
Depreciation:										
1938	5	44	81	126	53	13	322	(22)	(17)	361
1948	32	98	175	293	169	34	801	(54)	(46)	901
1949	36	105	185	318	174	35	853	(57)	(49)	959
1950	39	113	196	352	184	39	923	(62)	(51)	1,036
1951	47	133	221	423	208	44	1,076	(72)	(54)	1,202
1952	54	153	239	495	228	50	1,219	(82)	(45)	1,346
1953	58	161	262	516	233	52	1,282	(86)	(39)	1,407
Net fixed capital formation:										
1938	1	17	21	85	127	26	277	(18)	(—)	295
1948	26	58	7	186	173	9	459	(36)	(—)	495
1949	16	91	19	232	158	28	544	(41)	(—)	585
1950	12	101	18	288	147	37	603	(43)	(—)	646
1951	9	104	−9	303	164	53	624	(40)	(—)	664
1952	—	112	−19	260	261	65	679	(41)	(—)	720
1953	−7	138	15	260	398	75	879	(47)	(—)	926

(1) Plant and machinery only (including tractors).
(2) Plant and machinery and vehicles only.
(3) Road goods transport is included under "Manufacturing and distribution, etc."
(4) This heading includes education (other than private), sewerage and other local authority services, etc. Health services and certain other Central Government services are, however, excluded.
(5) These classes of asset are listed in Appendix B, section 16.
Figures in brackets are very approximate.

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TABLE 2

Gross and Net Fixed Capital Formation by Type of Asset. At current prices

£ *million*

	Buses, etc.	*Road Goods Vehicles*	*Passenger Cars* (1)	*Ships*	*Railway Rolling Stock*	*Aircraft*(2)	*Plant and Machinery*	*Housing*	*Other Buildings and Works*	*Total**
Gross fixed capital formation:										
1938 . .	12	26	9	21	14	1	177	180	159	599
1948 . .	33	71	34	56	28	8	482	342	206	1,260
1949 . .	38	75	48	57	29	12	541	332	265	1,397
1950 . .	35	75	45	67	31	8	616	331	318	1,526
1951 . .	24	81	56	66	33	7	713	372	348	1,700
1952 . .	21	83	57	66	27	10	762	489	383	1,898
1953 . .	18	93	60	100	37	10	795	631	417	2,161
Depreciation:										
1938 . .	10	23	8	18	12	1	112	53	85	322
1948 . .	13	41	14	44	23	3	292	169	202	801
1949 . .	15	45	17	48	24	4	318	174	208	853
1950 . .	18	54	20	52	27	3	346	184	219	923
1951 . .	21	71	31	55	29	3	400	208	258	1,076
1952 . .	24	82	40	57	32	5	469	228	282	1,219
1953 . .	25	82	40	74	33	5	502	233	288	1,282
Net fixed capital formation:										
1938 . .	2	3	1	3	2	—	65	127	74	277
1948 . .	20	30	20	12	5	5	190	173	4	459
1949 . .	23	30	31	9	5	8	223	158	57	544
1950 . .	17	21	25	15	4	5	270	147	99	603
1951 . .	3	10	25	11	4	4	313	164	90	624
1952 . .	−3	1	17	9	−5	5	293	261	101	679
1953 . .	−7	11	20	26	4	5	293	398	129	879

(1) Only cars bought by business users are included. The figures are of very doubtful reliability.
(2) The figures for aircraft are of doubtful reliability.

* This table omits certain classes of asset (mainly buildings) listed in Appendix B, section 16. The scope of the "Total" column of this table corresponds with that of the column headed "Sub-total" in Table 1.

capital formation at market prices in relation to national income and expenditure. I have not attempted to estimate net fixed capital formation at factor cost. To do this would have involved reallocating *some* of the indirect taxes shown in the *National Income Blue Book* as falling on gross fixed capital formation, viz. the taxes attributable to the capital consumption component of gross fixed capital formation; these taxes would be reallocated in part to net fixed capital formation, but mainly to the other forms of final expenditure (such as consumers' expenditure) on which the taxes ultimately fall.

45. Table 10 shows that the proportion of gross national product (at factor cost) required to make good depreciation has risen from 7 per cent. in 1938 to a present level of 9 to 10 per cent. Gross domestic fixed investment has been between 11½ and 14 per cent. of gross national product (at market prices). In the post-war years just under two-thirds of this gross investment was required to make good depreciation, and a little over one-third represented net investment; in 1938 the proportions were nearer half-and-half. Net fixed investment has been between 4½ and 6 per cent. of net national product (at market prices). It is important to note that the investment figures given in this paper all refer to domestic investment; that is, they include investment taking place in the United Kingdom but financed from foreign sources, and exclude investment overseas financed by the United Kingdom. This qualification must be borne in mind in interpreting the figures given here of the proportion of national resources devoted to investment.

46. Gross investment between the wars reached its highest level in the years 1936–1938; this

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TABLE 3

Gross Fixed Capital Formation in Each Industry Group, 1924–1953. *At constant* 1948 *prices*

£ *million*

	Agriculture(1)	*Coal*(2), *Gas, Electricity and Water*	*Transport and Communication*(3)	*Manufacturing and Distribution etc.*(3)	*Housing*	*Public and Social Services*(4)	*Total**
1924	7	98	243	249	243	30	870
1925	6	111	225	250	284	39	915
1926	7	112	195	272	333	38	957
1927	7	129	232	282	390	40	1,080
1928	6	117	235	300	285	42	985
1929	6	124	259	329	368	46	1,132
1930	7	131	232	318	317	61	1,066
1931	6	138	188	286	352	75	1,045
1932	6	131	130	249	328	59	903
1933	4	115	102	258	451	47	977
1934	8	115	134	334	532	50	1,173
1935	10	134	155	395	540	57	1,291
1936	12	147	204	472	522	68	1,425
1937	17	143	229	513	462	81	1,445
1938	12	138	242	474	474	91	1,431
1948	58	156	182	479	342	43	1,260
1949	50	190	200	532	327	62	1,361
1950	47	198	201	593	315	71	1,425
1951	46	196	179	595	318	79	1,413
1952	40	197	173	555	388	86	1,439
1953	37	220	199	570	500	94	1,620
Averages:							
1924–1929	7	115	232	280	317	39	990
1930–1934	6	126	157	289	396	59	1,033
1935–1938	13	140	208	464	499	74	1,398
1948–1953	46	193	189	554	365	73	1,420

(1) to (4) See corresponding footnotes to Table 1.

* See corresponding footnote to Table 2.

level was attained once again in the years 1950–1952, and has been substantially exceeded for the first time in 1953. But because of the greater quantity of assets now in use as compared with the pre-war period, the amount of resources required to make good depreciation is greater than pre-war. As a result the rate of net investment has reached the peak pre-war level only in 1953.

47. As a result of the reduced rate of investment during the war and of war losses, the net value of fixed assets at the end of 1947 appears to have been over £1,000 million—or 5 per cent.—below the level of 1938 (in terms of constant prices). By the end of 1950, however, the position had been restored, and at the end of 1953 the net value was some 10 per cent. above the end-1938 figure. The net value of fixed assets at the end of 1953 was about £26,000 million at the prices of 1948—or around £34,000 million at prices now current.†

The Position in Individual Industries

48. The amount of net investment taking place in different industry groups has varied considerably. In the fuel and power group, net investment has represented a substantial proportion of gross investment in the post-war years; this is a considerable improvement on the 1938 rate of net investment, so far as the gas industry and investment in plant and machinery in the coal mining industry are concerned.

† These figures include an allowance for assets not covered by Tables 7 and 8.

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TABLE 4

Gross Fixed Capital Formation by Type of Asset, 1924–1953. *At constant* 1948 *prices*

£ *million*

	Buses, etc.	*Road Goods Vehicles*	*Passenger Cars*(1)	*Ships*	*Railway Rolling Stock*	*Aircraft*(2)	*Plant and Machinery*	*Housing*	*Other Buildings and Works*	*Total**
1924 .	17	15	7	104	36	—	249	243	199	870
1925 .	17	15	8	77	40	—	263	284	211	915
1926 .	26	23	11	46	34	—	275	333	209	957
1927 .	27	24	12	81	36	—	290	390	220	1,080
1928 .	29	26	13	97	27	—	272	285	236	985
1929 .	31	36	18	107	29	—	287	368	256	1,132
1930 .	29	36	18	70	24	—	298	317	274	1,066
1931 .	26	39	19	25	16	—	275	352	293	1,045
1932 .	18	35	17	11	9	—	248	328	237	903
1933 .	10	37	18	10	12	—	228	451	211	977
1934 .	14	50	25	34	18	—	279	532	221	1,173
1935 .	18	50	25	35	29	—	323	540	271	1,291
1936 .	21	55	28	60	36	—	377	522	326	1,425
1937 .	23	58	29	62	36	—	420	462	355	1,445
1938 .	24	51	25	63	30	2	393	474	369	1,431
1948 .	33	71	34	56	28	8	482	342	206	1,260
1949 .	38	73	47	56	28	12	520	327	260	1,361
1950 .	35	68	44	61	28	7	566	315	301	1,425
1951 .	23	62	44	55	27	6	595	318	283	1,413
1952 .	18	57	40	54	20	7	566	388	289	1,439
1953 .	16	67	46	65	27	7	581	500	311	1,620
Averages:										
1924–1929 .	24	23	12	85	34	—	273	317	222	990
1930–1934 .	19	39	19	30	16	—	267	396	247	1,033
1935–1938 .	21	54	27	55	33	1	378	499	330	1,398
1948–1953 .	27	66	43	58	26	8	552	365	275	1,420

(1), (2), * See corresponding footnotes to Table 2.

49. Similarly in the group "manufacturing and distribution, etc.", net investment has represented a substantial proportion—nearly 40 per cent.—of gross investment in the post-war period. But this result probably obscures divergent trends between individual industries, in some of which (for example, oil refining) net investment has been very high, while in others net investment may have been low or even negative. Some indication of this divergence of experience is suggested by the figures for the commercial buildings component of this industry group (shops, offices, hotels, etc.); post-war net investment in these buildings appears to have been low, if not negative, in contrast with a considerable rate of net investment in such buildings in 1938. For plant and machinery and industrial buildings in this group of industries—mainly plant and buildings in manufacturing industry—there has been substantial net investment in the period 1948–1953 and at a higher rate than in 1938. The net value of plant and machinery (expressed in terms of constant prices) was about 45 per cent. higher at the end of 1953 than at the end of 1938; for industrial buildings the corresponding figure was 37 per cent. For road goods vehicles, most of which are included in this paper under manufacturing and distribution,† the rate of net investment has fallen off somewhat from the high levels of 1948–1950.

50. Net investment in agricultural machinery was a substantial proportion of gross investment in the earlier part of the period 1948–1953, but the level of gross investment has now fallen to near

† A note on the industrial classification of road vehicles appears in the introductory paragraph of Appendix B.

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TABLE 5

Gross and Net Fixed Capital Formation in Each Industry Group. At constant 1948 prices

£ *million*

	Agriculture(1)	*Coal*(2), *Gas, Electricity and Water*	*Transport and communication*(3)	*Manufacturing and Distribution, etc.*(3)	*Housing*	*Public and Social Services*(4)	*Total**
Gross fixed capital formation:							
1938 . .	12	138	242	474	474	91	1,431
1948 . .	58	156	182	479	342	43	1,260
1949 . .	50	190	200	532	327	62	1,361
1950 . .	47	198	201	593	315	71	1,425
1951 . .	46	196	179	595	318	79	1,413
1952 . .	40	197	173	555	388	86	1,439
1953 . .	37	220	199	570	500	94	1,620
Depreciation:							
1938 . .	9	100	192	283	141	30	755
1948 . .	32	98	175	293	169	34	801
1949 . .	34	102	181	307	172	35	831
1950 . .	36	105	184	326	175	36	862
1951 . .	38	110	186	346	178	36	894
1952 . .	40	114	189	362	181	37	923
1953 . .	42	119	191	379	184	38	953
Net fixed capital formation:							
1938 . .	3	38	50	191	333	61	676
1948 . .	26	58	7	186	173	9	459
1949 . .	16	88	19	225	155	27	530
1950 . .	11	93	17	267	140	35	563
1951 . .	8	86	−7	249	140	43	519
1952 . .	—	83	−16	193	207	49	516
1953 . .	−5	101	8	191	316	56	667
Percentage distribution of:							
Gross fixed capital formation, 1948–1953 . .	*3*	*14*	*13*	*39*	*26*	*5*	*100*
Net fixed capital formation, 1948–1953 . .	*2*	*15*	*1*	*40*	*35*	*7*	*100*
Net capital formation as a percentage of gross capital formation, 1948–1953 .	*20*	*44*	*2*	*39*	*52*	*50*	*38*

(1) to (4) See corresponding footnotes to Table 1.

* See corresponding footnote to Table 2.

"replacement level". A notable feature of investment in agricultural machinery is the rapid growth since 1938 in the stock of capital; the end-1953 net value appears to be four times the end-1938 figure (at constant prices). If buildings and works (e.g. drainage) had been taken account of in this paper the overall picture of agricultural investment might well have been different.

51. For housing, which represents some 40 per cent. of the net value of domestic capital, there has been a high rate of net investment in the post-war years. The rate of net investment achieved in 1953—about equal to the net rate of 1938—represented over 60 per cent. of the gross investment in housing. This may have been offset to some extent by excessive deterioration of existing houses

TABLE 6 *Gross and Net Fixed Capital Formation by Type of Asset. At constant 1948 prices*

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TABLE 6

Gross and Net Fixed Capital Formation by Type of Asset. At constant 1948 prices

£ *million*

	Buses, etc.	*Road Goods Vehicles*	*Passenger Cars*(1)	*Ships*	*Railway Rolling Stock*	*Aircraft*(2)	*Plant and Machinery*	*Housing*	*Other Buildings and Works*	*Total**
Gross fixed capital formation:										
1938 . . .	24	51	25	63	30	2	393	474	369	1,431
1948 . . .	33	71	34	56	28	8	482	342	206	1,260
1949 . . .	38	73	47	56	28	12	520	327	260	1,361
1950 . . .	35	68	44	61	28	7	566	315	301	1,425
1951 . . .	23	62	44	55	27	6	595	318	283	1,413
1952 . . .	18	57	40	54	20	7	566	388	289	1,439
1953 . . .	16	67	46	65	27	7	581	500	311	1,620
Depreciation:										
1938 . . .	21	45	22	53	25	1	249	141	198	755
1948 . . .	13	41	14	44	23	3	292	169	202	801
1949 . . .	15	44	16	48	23	4	305	172	204	831
1950 . . .	18	49	20	48	24	3	318	175	207	862
1951 . . .	20	54	24	47	24	3	334	178	210	894
1952 . . .	21	56	28	48	24	3	349	181	213	923
1953 . . .	22	59	31	48	24	3	367	184	215	953
Net fixed capital formation:										
1938 . . .	3	6	3	10	5	1	144	333	171	676
1948 . . .	20	30	20	12	5	5	190	173	4	459
1949 . . .	23	29	31	8	5	8	215	155	56	530
1950 . . .	17	19	24	13	4	4	248	140	94	563
1951 . . .	3	8	20	8	3	3	261	140	73	519
1952 . . .	−3	1	12	6	−4	4	217	207	76	516
1953 . . .	−6	8	15	17	3	4	214	316	96	667
Percentage distribution of:										
Gross fixed capital formation, 1948–1953 . . .	*1·9*	*4·7*	*3·0*	*4·1*	*1·8*	*0·5*	*38·9*	*25·7*	*19·4*	*100*
Net fixed capital formation, 1948–1953	*1·7*	*2·9*	*3·7*	*2·0*	*0·5*	*0·9*	*41·3*	*34·7*	*12·3*	*100*
Net capital formation as a percentage of gross capital formation, 1948–1953	*33*	*24*	*48*	*18*	*10*	*60*	*41*	*52*	*24*	*38*

(1), (2), * See corresponding footnotes to Table 2.

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TABLE 7

Gross and Net Fixed Capital in Each Industry Group. At constant 1948 prices

£ *million*

	Agriculture(1)	*Coal*(2), *Gas, Electricity and Water*	*Transport and Communication*(3)	*Manufacturing and Distribution, etc.*(3)	*Housing*	*Public and Social Services*(4)	*Total**
Gross fixed capital:							
End of 1938 .	89	3,653	8,379	9,755	14,051	2,308	38,235
„ „ 1947 .	272	3,636	7,710	9,844	14,538	2,522	38,522
„ „ 1952 .	398	4,162	7,772	11,574	15,981	2,792	42,679
Accrued depreciation:							
End of 1938 .	41	1,642	4,371	4,310	4,710	870	15,944
„ „ 1947 .	132	1,918	4,152	4,583	5,469	1,095	17,349
„ „ 1952 .	197	2,036	4,194	5,193	6,097	1,202	18,919
Net fixed capital:							
End of 1938 .	48	2,011	4,008	5,445	9,341	1,438	22,291
„ „ 1947 .	140	1,718	3,558	5,261	9,069	1,427	21,173
„ „ 1948 .	166	1,776	3,565	5,447	9,242	1,436	21,632
„ „ 1949 .	182	1,864	3,584	5,672	9,397	1,463	22,162
„ „ 1950 .	193	1,957	3,601	5,939	9,537	1,498	22,725
„ „ 1951 .	201	2,043	3,594	6,188	9,677	1,541	23,244
„ „ 1952 .	201	2,126	3,578	6,381	9,884	1,590	23,760
„ „ 1953 .	196	2,227	3,586	6,572	10,200	1,646	24,427
Percentage distribution of net fixed capital at end of 1953 . . .	*1*	*9*	*14*	*27*	*42*	*7*	*100*

(1) to (4) See corresponding footnotes to Table 1.

* See corresponding footnote to Table 2.

through failure to carry out adequate repairs and maintenance, but this aspect is not taken account of in the figures here presented.

52. In public and social services, which include, for example, schools (other than private), sewerage undertakings, local government offices, etc., the level of gross investment has risen from a little above replacement level in 1948 until it now includes a very substantial element of net investment. Hospitals are excluded from the figures for "public and social services" given in this paper.

53. One of the most striking of the conclusions on rates of net investment refers to the transport and communication field (excluding road goods transport operators and "C" licence operators whose vehicles are here included in the manufacturing and distribution group). Whereas in 1938 the level of gross investment was enough to permit a modest element of net investment, the post-war level of gross investment has been barely above the "replacement level".

54. Within the transport field there have however been marked contrasts. In shipping there would seem to have been a moderate rate of net investment, so that the net value of the fleet is now greater (in terms of constant prices) than at the end of 1938. This latter conclusion in no way contradicts the fact that the gross value of the fleet (a measure of the size of the fleet taking no account of its age distribution) is less than in 1938; the figures in Table 13 confirm that the fleet tonnage is at present no larger than in 1938, and in fact, if allowance is made for the reduced tonnage of the more highly priced passenger vessels and the increased tonnage of the cheaper tankers, the gross value does show a reduction compared with 1938. It follows that the average unexpired life of ships is now greater than in 1938; post-war replacements have "rejuvenated" the fleet.

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TABLE 8

Gross and Net Fixed Capital by Type of Asset†. At constant 1948 prices

£ *million*

	Buses, etc.	*Road Goods Vehicles*	*Pass-enger Cars*(1)	*Ships*	*Railway Rolling Stock*	*Air-craft*(2)	*Plant and Machinery*	*Housing*	*Other Buildings and Works*	*Total**
Gross fixed capital:										
End of 1938	210	446	222	1,256	756	3	6,964	14,051	14,327	38,235
„ „ 1947	123	386	126	1,016	688	14	7,404	14,538	14,227	38,522
„ „ 1952	212	561	283	1,139	734	43	9,055	15,981	14,671	42,679
Accrued depreciation:										
End of 1938	122	224	111	645	387	2	3,205	4,710	6,538	15,944
„ „ 1947	68	185	60	378	363	2	3,667	5,469	7,157	17,349
„ „ 1952	97	273	110	454	396	7	4,187	6,097	7,298	18,919
Net fixed capital:										
End of 1938	88	222	111	611	369	1	3,759	9,341	7,789	22,291
„ „ 1947	55	201	66	638	325	12	3,737	9,069	7,070	21,173
„ „ 1948	75	231	86	650	330	17	3,927	9,242	7,074	21,632
„ „ 1949	98	260	117	658	335	25	4,142	9,397	7,130	22,162
„ „ 1950	115	279	141	671	339	29	4,390	9,537	7,224	22,725
„ „ 1951	118	287	161	679	342	32	4,651	9,677	7,297	23,244
„ „ 1952	115	288	173	685	338	36	4,868	9,884	7,373	23,760
„ „ 1953	109	296	188	702	341	40	5,082	10,200	7,469	24,427
Percentage distribution of net fixed capital at end of 1953 . .	*0·4*	*1·2*	*0·8*	*2·9*	*1·4*	*0·2*	*20·8*	*41·7*	*30·6*	*100*

(1), (2), * See corresponding footnotes to Table 2.

† Estimates of the gross and net value of fixed capital analysed by type of asset and expressed in terms of *current* prices may be obtained by multiplying the figures in this table by the price indices given in Appendix A.

55. For road passenger transport (i.e. bus undertakings), the high level of gross investment of 1948–1950 has now fallen off to near "replacement level". In the Post Office, there has been steady net investment, though the post-war rate of net investment seems to be below the 1938 level. In air transport—a relatively new industry—the major part of gross investment has represented net investment.

56. The marked contrasts to this pattern occur in two of the older established industries—railways and ports—and in roads. The levels of gross investment in post-war years have been inadequate to make good depreciation including obsolescence (on the definitions here employed). The negative figures of net investment in these industries should not be interpreted as meaning that the *quantity* of assets in use has fallen, but rather that the average age of assets in use has increased. Considering railway rolling stock by itself, the level of gross investment has been slightly above replacement level, but has not been adequate to make good arrears accumulated during the war. Although the net value of rolling stock is thus less than in 1938, the *gross* value, which is a measure of the volume or quantity of rolling stock in use taking no account of its age distribution, is little different from the 1938 level (a fact confirmed by the quantity figures given in Table 13). This suggests that the average age of rolling stock is now somewhat greater than in 1938 or, to put it the other way round, the average unexpired life is less than in 1938.

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TABLE 9—*Gross and Net Fixed Capital*

	Fuel and Power, and Water					
	Coal(1)	*Gas*	*Electricity*	*Water*	*Railways*	*Road Passenger Transport*
At Current Prices.						
Gross fixed capital formation:						
1938	3	8	40	10	24	15
1948	18	26	99	13	36	35
1949	23	29	124	20	38	40
1950	18	34	138	24	40	39
1951	18	41	150	28	42	29
1952	26	46	159	34	36	26
1953	36	47	178	38	49	23
Net fixed capital formation:						
1938	1	1	14	1	−4	4
1948	12	12	39	−5	−21	19
1949	16	14	60	1	−20	22
1950	11	17	68	5	−19	19
1951	10	20	69	5	−26	4
1952	16	23	64	9	−37	−2
1953	25	22	79	12	−24	−6
At Constant Prices of 1948.						
Gross fixed capital formation:						
Average 1924–1929	6	21	69	19	47	30
„ 1930–1934	5	14	90	17	34	24
„ 1935–1938	6	18	97	19	48	28
„ 1948–1953	19	32	120	22	35	30
1938	7	18	91	22	53	31
1948	18	26	99	13	36	35
1949	22	28	120	20	37	40
1950	16	32	127	23	38	39
1951	15	34	124	23	34	27
1952	19	35	118	25	27	22
1953	26	35	131	28	36	20
Net fixed capital formation:						
1938	2	1	31	4	−10	8
1948	12	12	39	−5	−21	19
1949	15	14	58	1	−20	23
1950	9	16	63	5	−18	19
1951	8	17	57	4	−21	4
1952	11	17	48	7	−28	−2
1953	18	16	58	9	−18	−5
Gross fixed capital:						
End of 1938	148	500	1,617	1,388	4,146	308
„ „ 1947	151	431	1,678	1,376	3,784	233
„ „ 1952	216	494	2,067	1,385	3,548	331
Net fixed capital:						
End of 1938	71	242	1,006	692	1,758	158
„ „ 1947	79	192	851	596	1,454	120
„ „ 1952	134	268	1,116	608	1,346	183
„ „ 1953	152	284	1,174	617	1,328	178

(1) Plant and machinery and vehicles only.

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Formation in Individual Industries

£ *million*

Transport and Communication					*Manufacturing and Distribution, etc.*(2)			
Roads	*Shipping*	*Harbours, Docks and Canals*	*Air Transport*	*Postal and Telephone Communication*	*Vehicles*	*Plant and Machinery*	*Industrial Buildings*	*Commercial Buildings*
15	20	2	1	25	32	104	23	52
6	53	6	12	34	99	275	90	15
8	53	8	17	40	114	312	98	26
8	64	9	13	41	113	367	114	46
8	64	9	13	47	125	440	118	43
9	64	11	15	59	127	458	131	39
10	98	13	17	67	141	456	140	39
8	3	−4	1	13	4	40	7	34
−8	10	−5	8	4	49	114	48	−25
−7	7	−3	11	9	57	136	53	−14
−8	13	−3	8	8	45	174	66	3
−9	9	−5	8	10	32	216	61	−6
−10	11	−4	8	15	14	193	69	−16
−11	28	−1	10	19	27	174	75	−16
27	81	10	—	37	32	148	34	66
32	27	8	—	32	54	130	34	71
28	52	4	1	47	74	218	63	109
7	55	8	13	41	101	325	99	29
34	60	5	2	57	70	230	54	120
6	53	6	12	34	99	275	90	15
8	52	8	16	39	111	300	96	25
7	58	8	12	39	105	337	108	43
7	53	7	11	40	97	367	96	35
7	53	8	11	45	88	339	99	29
7	64	10	13	49	104	333	104	29
19	11	−8	2	28	8	88	17	78
−8	10	−5	8	4	49	114	48	−25
−7	7	−3	11	8	56	131	52	−14
−8	12	−3	8	7	42	160	62	3
−8	7	−4	7	8	25	180	49	−5
−7	7	−3	6	11	10	143	52	−12
−8	18	−1	8	14	20	127	56	−12
1,059	1,174	955	10	727	608	4,141	1,865	3,141
1,082	954	803	51	803	464	4,346	2,071	2,963
1,072	1,075	752	104	890	773	5,399	2,392	3,010
662	572	413	7	438	302	2,127	1,016	2,000
594	603	305	41	441	241	2,234	1,074	1,712
556	646	287	81	479	423	2,962	1,337	1,659
548	664	286	89	493	443	3,089	1,393	1,647

(2) Including road goods transport and vehicles employed in agriculture.

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TABLE

Net Fixed Capital Formation in Relation

£ *million*

Income	*1938*	*1948*	*1949*	*1950*	*1951*	*1952*	*1953*
1. National income	4,771	9,349	10,011	10,509	11,513	12,392	13,389
2. Indirect taxes *less* subsidies	585	1,449	1,457	1,586	1,804	1,867	2,015
3. Net national product at market prices	5,356	10,798	11,468	12,095	13,317	14,259	15,404
4. Depreciation	361	901	959	1,036	1,202	1,346	1,407
5. Gross national product at market prices	5,717	11,699	12,427	13,131	14,519	15,605	16,811

The following percentages may be derived:

	1938	*1948*	*1949*	*1950*	*1951*	*1952*	*1953*
Depreciation as a percentage of gross national product at factor cost(2)	*7·0*	*8·8*	*8·7*	*9·0*	*9·5*	*9·8*	*9·5*
Gross fixed capital formation as a percentage of gross national product at market prices	*11·5*	*11·9*	*12·4*	*12·8*	*12·9*	*13·2*	*13·9*
Net fixed capital formation as a percentage of net national product at market prices	*5·5*	*4·6*	*5·1*	*5·3*	*5·0*	*5·0*	*6·0*
Net fixed capital formation as a percentage of gross fixed capital formation	*45*	*35*	*38*	*38*	*36*	*35*	*40*

57. Railways, ports and roads are three of the industries (if indeed we can speak of roads, divorced from the vehicles that run on them, as an "industry") to which the remarks in paragraph 25 are applicable. That is to say, each of them involves civil engineering works of a very permanent character, to which only most arbitrary lengths of life can be given. If no depreciation at all were to be allowed in respect of "everlasting" assets, the level of net investment would be higher (i.e. the level of net disinvestment would be less) than is stated in this paper. A study of the composition of railway investment suggests, however, that if no depreciation were to be allowed for the permanent way, but only for rolling stock, vehicles, plant and buildings, the estimates of post-war net investment in this industry would still be negative.

58. Tables 3, 4 and 9, which give historical series for gross investment at constant prices, add support to these conclusions. They suggest that in the manufacturing and distribution group post-war gross investment has been some 20 per cent. above the 1935–1938 rate and nearly double the rate of the decade 1924–1934. For plant and machinery and industrial buildings taken separately, gross investment in 1948–1953 was in each case about 50 per cent. over the 1935–1938 level and well over twice the level of 1924–1934. But for commercial buildings (offices, shops, hotels, etc.) post-war gross investment appears to have been well below the level of any of the inter-war period.

59. In the fuel and power group post-war investment appears to have been substantially above the pre-war level.

60. In transport and communication (excluding road goods transport and "C" licence vehicles) the post-war level of gross investment in the group as a whole is below the levels of 1924–1929 and 1935–1938, but not so low as the level of the 1930–1934 depression. This reduction in the level of gross investment is accounted for mainly by the much lower level of investment in railways and roads. The post-war level of capital expenditure on the railways is about equal to the low level in the depression of 1930–1934. For railway buildings and works considered by themselves, the post-war level of capital expenditure compares very unfavourably with that of any inter-war period, and the same conclusion applies to roads. It is worth mentioning in passing that the figures of gross investment in railways and roads are not directly comparable, since the former include all rolling stock, whereas the figures for roads exclude all the vehicles running on them.

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10

to National Income and Expenditure (1)

£ *million*

Expenditure at Market Prices	*1938*	*1948*	*1949*	*1950*	*1951*	*1952*	*1953*
6. Net domestic fixed capital formation	295	495	585	646	664	720	926
7. Other final expenditure	5,061	10,303	10,883	11,449	12,653	13,539	14,478
8. Net national expenditure at market prices	5,356	10,798	11,468	12,095	13,317	14,259	15,404
9. Depreciation	361	901	959	1,036	1,202	1,346	1,407
10. Gross national expenditure at market prices	5,717	11,699	12,427	13,131	14,519	15,605	16,811

(1) The sources for items 2 and 5 of this Table are *National Income Blue Book*, 1954, Table 1, and *Annual Abstract of Statistics*, No. 91, Table 282. Strictly gross national product at market prices (item 5) is underestimated. The reason is that one of the elements in building up estimates of gross national expenditure represents the imputed rental payments for the owner-occupation of houses, and for the owner-use of assets by the non-trading branches of public authorities; and these imputed rental payments generally include either no allowance for depreciation or an allowance based on original cost. This understatement, which involves a corresponding understatement in the figure for national income, is probably not sufficiently important to invalidate the conclusions drawn in this paper.

(2) Gross national product at factor cost is the sum of items 1 and 4 of this Table.

61. In housing the pre-war peak level of gross investment was reached in the period 1933–1938. This level was again reached in 1953.

62. Considering all new buildings and civil engineering works together, including houses,* the post-war level of gross investment up to 1952 appears to have been well below the best inter-war levels; but the pre-war peak level was reached again in 1953.

The Distribution of the Net Value of Capital Assets between Industries and Types of Asset

63. The estimates of the net value of capital in Tables 7 and 8 must be qualified in two ways. Firstly, they omit some classes of asset mainly on the building side. Secondly, the magnitude of the estimates relies fairly heavily on the assumptions about length of life. We may, however, draw the following general conclusions. Some 75 per cent. of the net value of fixed assets consists of buildings and works, and over half of this is housing. Plant and machinery and vehicles, though they account for over half of post-war gross investment and around 40 per cent. of gross investment in the 1930's, represent about a quarter of the net value of fixed assets; the length of life of plant and vehicles is, of course, shorter than that of buildings.

64. Outside the field of housing and public and social services, about half the net value of fixed capital is invested in the manufacturing and distribution group of industries and the remaining half in the "public utility" field (that is fuel and power industries, water, and transport and communication).

VI. *Comments on the Supplementary Tables* 11 *to* 13

Capital to Output Ratios in Different Industries

65. It is instructive to compare the gross capital employed in various industries with their respective annual contributions to gross national product; this contribution is a measure of each industry's "net output" reckoned *before* deduction of depreciation. Table 11 shows the comparison, and it also gives figures of depreciation (at replacement cost) for each industry.

* Buildings and works for the Armed Services, other than married quarters, are however excluded.

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66. Table 11, column (*e*), shows that for the "public utilities" (gas, electricity, water, railways and postal and telephone communication), as well as for shipping, depreciation (at replacement cost) represented 20 per cent. or more of their net output in 1952, but that for the manufacturing and distribution group as a whole the percentage was only 6. Column (*d*) shows that the gross capital employed in the same public utilities was over 6 times their annual net output; for railways and electricity the ratio was some 15 times, and for water 46 times. For the manufacturing and distribution group, however, the gross capital employed was about 1·8 times their annual net output. These figures should be treated with caution, because (i) it has only been possible to get approximate agreement between the industrial classification of the net output figures and the classification of investment, (ii) the gross capital figures are, for reasons already given, liable to considerable error, and (iii) the ratio of gross capital to annual net output is dependent on whether the assets in question are being fully employed or not. Despite these qualifications the table shows quite clearly the much heavier capital requirements per unit of output in the "public utility" field than in the manufacturing and distribution field.

The Relationship between Depreciation at Original Cost and Depreciation at Replacement Cost

67. Table 12 gives estimates of depreciation at *original* cost and at replacement cost for five particular groups of assets, viz. gas, electricity, railway rolling stock, postal and telephone communication, and plant and machinery in the manufacturing and distribution group of industries. The estimates at original cost have been derived in exactly the same way as the estimates of depreciation at replacement cost (that is, as in the example set out in paragraph 13) except that an historical series for gross fixed investment at *current* (i.e. original) cost has been used in place of the constant price series. These estimates of depreciation at original cost are compared in Table 12 with depreciation at original cost as published in the accounts of the undertakings concerned (except in the case of the manufacturing and distribution industries for which no such figures are available).* The table shows good agreement between the alternative sets of figures at original cost. So far as the assets covered by the table are concerned I therefore conclude: firstly, that my estimates

TABLE 11

Relationship between the Gross Capital Employed in certain Industries, their Contributions to Gross National Product, and Depreciation. Year 1952

Industry	*Gross Capital at End of Year*(1) £ *million* (*a*)	*Depreciation in Year*(1) £ *million* (*b*)	*Contribution to Gross National Product*(2) £ *million* (*c*)	*Ratio of* (*a*) : (*c*) (*d*)	*Ratio of* (*b*) : (*c*) (*e*)
Gas	665	23	98	6·8	0·23
Electricity	2,783	95	170	16·4	0·56
Water	1,844	25	40	46	0·63
Railways	4,740	73	310	15·3	0·24
Road passenger transport	400	28	165	2·4	0·17
Shipping	1,666	53(4)	275	6·0	0·19
Postal and telephone communication	1,200	44	185	6·5	0·24
Manufacturing, distribution and other transport, etc.(3)	16,734	517	9,265	1·8	0·06
Total of industries above	30,032	858	10,508	2·9	0·08

(1) At replacement costs of 1952.

(2) The estimates in this column are a subdivision of those given in Table 10(i) of the *National Income Blue Book*, 1954.

(3) This item corresponds to the following headings in Table 9: manufacturing and distribution, etc.; harbours, docks and canals; and air transport.

(4) The excess of the proceeds of sales during the year of second-hand ships to foreign owners *over* their written-down replacement value has been deducted in arriving at depreciation. In the absence of such sales a higher figure of depreciation would appear in this table.

* All the published depreciation figures shown in Table 12 are based on the "straight-line" rule.

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for earlier years of gross fixed investment at current prices are not seriously in error; and, secondly, the fact that my estimates of depreciation at original cost have necessarily been worked out in far less detail than the published figures of depreciation does not seem to have introduced substantial error.

68. The figures in Table 12 suggest that for a considerable range of plant and machinery depreciation at current replacement cost in the years 1948 to 1953 was nearly twice the depreciation at original cost, and that the net value of assets at the end of 1952 at 1952 replacement cost was about 1·6 or 1·7 times the net value at original cost. It is important to note, however, that the ratios just quoted are dependent on the assumption made throughout this paper that depreciation is calculated on a straight-line rule. Thus, if depreciation is calculated on the reducing balance principle, the ratio of replacement cost depreciation to original cost depreciation may be much less than the 2 : 1 mentioned above. This is because with the reducing balance formula a relatively heavier weight is attached to recent purchases (for which the ratio of replacement cost to original cost is nearer unity) than to earlier purchases.

Comparisons with Statistics of the Physical Quantity of Assets in Use

69. I have already explained that the methods adopted in this paper are one particular way of measuring the growth of assets, but not the only one. An obvious alternative is to measure the change in the physical quantity of assets in use (e.g. number of road vehicles in use). Unfortun-

TABLE 12

Depreciation and the Net Value of Fixed Assets Evaluated at Original Cost, Compared with the same Evaluated at Replacement Cost

£ million

	Gas		*Electricity*(1)		*Railway Rolling Stock*(2)		*Postal and Telephone Communication*		*Plant and Machinery in Manufacturing and Distribution, etc.*
	P	*C*	*P*	*C*	*P*	*C*	*P*	*C*	*C*
Depreciation at original cost:									
1948	..	7	..	29	12	12	18	17	85
1949	..	8	33	33	13	12	20	18	95
1950	11	10	36	37	13	13	22	20	108
1951	12	11	40	42	14	13	22	22	124
1952	14	13	44	47	15	14	23	24	142
1953	16	15	50	52	15	15	26	27	161
Depreciation at the replacement cost of each year:									
1948	..	14	..	58	..	22	..	30	161
1949	..	15	..	63	..	23	..	31	176
1950	..	17	..	69	..	26	..	33	193
1951	..	21	..	80	..	28	..	37	224
1952	..	23	..	93	..	31	..	44	265
1953	..	25	..	97	..	32	..	48	282
Net value of fixed assets at end of 1952:									
At original cost	275(3)	225	889(3)	888	286	247	352	344	2,521
At the replacement cost of 1952	..	360	..	1,472	..	433	..	644	4,000

P = Published in the accounts of the undertakings concerned (for sources see Appendix C).
C = Calculated.
(1) Great Britain only.
(2) British Transport Commission rolling stock only.
(3) Including land.

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TABLE 13.—*Quantity of Capital (in Physical Units) Employed in Great Britain, Compared with Indices*

	Unit	1927	1931	1935	1938
					For the indices, end
1. Agricultural machinery:					
Weighted index of number of machines in use(2)		..	..	..	..
Index of gross capital		..	..	..	*22*
2. Coal mining machinery in deep mines:					
Horsepower of electric motors installed(3)	000 H.P.	1,667	1,817	1,996	2,229
Index of horsepower of electric motors		*51*	*55*	*61*	*68*
„ „ gross capital		..	..	..	*69*
3. Electricity:					
Generating plant capacity	000 M.W.	5·3	7·2	8·1	9·4
Number of consumers	Million	2·6	4·6	7·7	10·1
Index of generating plant capacity		*30*	*40*	*46*	*53*
„ „ number of consumers		*18*	*33*	*55*	*72*
„ „ gross capital		..	..	..	*78*
4. Railway rolling stock(4):					
Locomotives (empty weight)	000 tons	1,084(5)	1,054	993	985
Passenger carriages	000	52·5	50·0	47·3	47·2
Wagons and containers (capacity)	Million tons	15·0(6)	..	..	15·3(6)
Weighted index of quantity of rolling stock(7)		*105*	..	..	*100*
Index of gross capital		..	..	..	*103*
5. Road passenger transport vehicles(8):					
Buses, 9–40 seats	000	36·3	39·4	34·0	33·8
„ 41 and over seats	000	6·4	9·7	12·0	16·5
Trolley vehicles	000	..(9)	..(9)	1·18	2·72
Tramcars	000	14·1	13·01	10·87	9·0
Total number	000	56·8	62·1	58·1	62·0
Weighted index of number of vehicles(10)		*70*	*76*	*72*	*76*
Index of gross capital		..	..	..	*99*
6. Road goods vehicles (total employed in all industries)(8)(11):					
Not exceeding 1½ tons unladen weight	000	184	215	206	210
Exceeding 1½ tons but not exceeding 4 tons unladen weight	000	65	110	203	262
Exceeding 4 tons unladen weight	000	34	36	26	23
Total number	000	283	361	435	495
Weighted index of number of vehicles(12)		*28*	*36*	*45*	*52*
Index of gross capital		..	..	..	*80*
7. Ships (total employed in all industries)(13):					
Passenger vessels	Million gross tons	..	..	..	..
Dry cargo vessels	„ „ „	..	..	..	..
Tankers	„ „ „	..	..	..	..
Total tonnage	„ „ „	18·13	19·03	16·25	16·72
Weighted index of gross tonnage(14)		..	..	..	..
Index of gross capital		..	..	..	*110*
8. Postal and telephone communication(15):					
Length of single wire in telephone and telegraph system	Million miles	7·5	10·2	12·5	15·3
Telephone stations	Million	1·64	2·07	2·58	3·24
Index of length of single wire		*25*	*34*	*42*	*51*
„ „ number of telephone stations		*28*	*35*	*44*	*55*
„ „ gross capital		..	..	..	*82*

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of the Gross Value of Capital Derived from Tables 7 to 9. Figures refer to the end of each year (1).

of 1952 = 100

1939	1945	1946	1947	1948	1949	1950	1951	1952	1953
..	*63*	..	*73*	..	*87*	..	*94*	..	*106*
..	..	..	*68*	..	..	..	..	*100*	..
2,286	2,554	2,633	2,718	2,797	2,954	3,036	3,148	3,289	3,418
70	*78*	*80*	*83*	*85*	*90*	*92*	*96*	*100*	*104*
..	..	..	*70*	..	..	..	..	*100*	..
9·7	12·3	12·5	13·0	13·2	13·9	15·1	16·3	17·8	19·3
10·6	11·0	11·5	11·9	12·3	12·7	13·2	13·7	14·1	..
54	*69*	*70*	*73*	*74*	*78*	*85*	*92*	*100*	*108*
75	*78*	*82*	*84*	*87*	*90*	*94*	*97*	*100*	..
..	..	..	*81*	..	..	..	..	*100*	..
987	1,037	1,054	1,051	1,078	1,066	1,062	1,044	1,041	1,034
47·6	45·0	44·7	44·5	44·5	45·4	46·5	46·3	46·2	46·1
15·3	15·9	15·8	15·7	15·1	14·6	14·7	15·0	15·1	15·3
101	*102*	*102*	*101*	*100*	*98*	*99*	*100*	*100*	*100*
..	..	..	*94*	..	..	..	..	*100*	..
..	..	29·9	33·6	36·8	40·6	41·6	41·2	40·4	38·5
..	..	23·5	25·0	27·5	29·4	31·8	33·8	35·3	37·3
..	..	3·84	3·87	4·21	4·06	4·18	4·06	4·03	3·93
7·9	6·2	6·12	5·75	5·56	5·25	4·61	4·21	3·64	3·01
..	..	63·4	68·2	74·1	79·3	82·2	83·3	83·4	82·8
..	..	*78*	*83*	*90*	*96*	*99*	*100*	*100*	*99*
..	..	..	*58*	..	..	..	..	*100*	..
..	..	220	259	315	355	384	407	436	468
..	..	314	380	420	451	471	484	482	479
..	..	26	30	34	37	40	43	45	48
488	473	560	669	769	843	895	934	963	995
..	..	*60*	*72*	*82*	*89*	*94*	*98*	*100*	*102*
..	..	..	*69*	..	..	..	..	*100*	..
3·91									
9·95	2·83	2·76	2·86	2·96	2·98	2·94	2·99	2·94	2·82
3·03	7·71	7·94	9·25	9·50	9·66	9·67	9·35	9·23	9·36
16·89	2·70	2·96	3·40	3·59	3·68	3·95	4·19	4·43	4·64
107	13·24	13·66	15·51	16·05	16·32	16·56	16·53	16·60	16·82
..	*83*	*85*	*95*	*98*	*100*	*101*	*100*	*100*	*100*
	..	..	*89*	..	..	..	..	*100*	..
..									
3·34	23·8	24·3	25·0	26·0	26·9	27·8	28·9	29·9	..
..	3·94	4·32	4·65	4·92	5·17	5·43	5·72	5·93	6·15
56	*80*	*81*	*84*	*87*	*90*	*93*	*97*	*100*	..
..	*66*	*73*	*78*	*83*	*87*	*92*	*96*	*100*	*104*
	..	..	*90*	..	..	..	..	*100*	..

(Notes to Table 13 on p. 168.)

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ately such statistics of physical quantities exist only for a limited number of classes of assets. For these few classes, however, it is interesting to compare the changes through time in the quantity of assets in use with the changes in the volume of capital employed as derived by the methods set out earlier in this paper. The figures of the net value of capital given in this paper take account not only of the quantity of assets, but also of their average unexpired life—the "two-dimensional" concept; it is therefore the figures of the gross value of capital—which do not take account of the time-factor (i.e. are "one-dimensional")—which can be most closely related to statistics of the physical quantity of assets in use.

70. Table 13 shows for eight groups of assets statistics of the quantity of assets in use in physical units for the period 1927 to 1953; these series have also been expressed in index form taking 1952 = 100. Alongside these indices appear the corresponding estimates of the gross value of capital evaluated at constant 1948 prices and also expressed in index form (with 1952 = 100); the latter indices have been derived directly from Tables 7 to 9 of this paper. Only gross capital figures for the end of 1938, 1947 and 1952 are shown, because the estimated changes in the gross value of capital over short periods of time, such as a year, are likely to contain large errors arising from errors in the assumptions about length of life.

71. For some groups of assets the index of gross capital is in fairly good agreement with the index of physical quantity—for example, for agricultural machinery, railway rolling stock and ships. For other assets the agreement is less good, and for some it is distinctly poor. That this should be so is not altogether surprising. In some instances the causes may be errors in the figures of gross value of capital resulting from errors in the lengths of life assumed, or in the price indices employed, or in the series for gross investment in the past. In other instances the statistics of physical units employed may be an inadequate or incomplete measure of the volume of capital. For example, electricity generating capacity is a measure of only one part of the capital employed in the electricity industry, and the series for number of consumers is a poor measure of the capital on the distribu-

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NOTES TO TABLE 13

(1) Unless otherwise stated, figures of quantity of assets refer to a date between October 1st of the stated year and March 31st of the following year. For sources of the statistics of quantity, see Appendix C.

(2) This index has been derived from statistics of numbers of machines in use; the series for different classes of machine have been weighted by average 1945 values per machine. For this index, the average of end-1951 and end-1953 has been taken to be 100.

(3) Figures refer to June 30th. For 1946 and earlier the figures include certain mines not producing coal; on this basis the 1947 figure is 2,737.

(4) For 1948 and later, the figures of quantity of rolling stock exclude certain minor lines not nationalised.

(5) Figure for 1928.

(6) The components of the figures for 1927 and 1938 relating to private owners' wagons refer respectively to 1928 and 1937.

(7) The following weights (which relate to approximate replacement costs in 1948) have been used: Locomotives, £150 per ton empty weight. Passenger carriages, £5,000 each. Wagons and containers, £25 per ton capacity.

(8) Figures of numbers of vehicles refer to vehicles for which licences were current at any time during the quarter ended September 30th, except for the figures for 1939 and 1945 which refer to vehicles with licences current at August 31st.

(9) Included under the heading "Buses".

(10) The following weights (which relate to approximate replacement costs in 1948) have been used: Buses 9–40 seats, £3,450 each. Buses 41 seats and over, £4,100 each. Trolley vehicles and tramcars, £5,600 each.

(11) Figures of numbers of vehicles exclude "exempt" vehicles.

(12) The following weights (which relate to approximate replacement costs in 1948) have been used: Not exceeding 1½ tons unladen weight, £420 each. Exceeding 1½ tons, but not exceeding 4 tons, £875 each. Exceeding 4 tons, £1,650 each.

(13) The figures of tonnage refer to vessels of 500 gross tons and over on the United Kingdom register excluding (i) vessels on bareboat charter or requisition from other registers, (ii) Canadian-owned tonnage permanently transferred to the United Kingdom register, (iii) craft not mechanically propelled, and (iv) (from 1939 onwards) miscellaneous non-trading craft. The 1939 figures refer to September 3rd.

(14) The following weights (which relate to approximate replacement costs in 1948) have been used: Passenger vessels, £119 per gross ton. Dry cargo vessels, £79 per gross ton. Tankers, £53 per gross ton.

(15) All figures refer to the United Kingdom.

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tive side of the industry. Similarly, numbers of machines, without any adjustment for size or complexity, cannot be regarded as a very satisfactory measure of the volume of capital in an industry.

72. It is not possible in every case to identify precisely the causes of divergence between the alternative indices of the volume of capital given in Table 13. But in the two cases where the discrepancy is largest—road passenger transport vehicles (mainly buses) and road goods vehicles—the divergence is accounted for almost wholly by errors in the assumed lengths of life. In fact, post-war buses are being kept in service for much longer than pre-war. The number of buses and trolley buses in use at the end of 1938 represented the vehicle intake of the preceding 9·3 years, whereas both at the end of 1947 and at the end of 1952 the number in service equalled the intake of the preceding 16·3 years. The calculated figures of the gross capital value of road passenger transport vehicles in Table 8 assume a life of 10 years for buses, so that the estimates relating to the end of 1947 and the end of 1952 necessarily understate the gross value of capital in use. A similar explanation applies to road goods vehicles.

73. The conclusion to be drawn from Table 13 is that, in the absence of supporting evidence, the reliability of the gross value figures as a measure of the change in volume of capital employed must always be in doubt. But I have explained earlier (paragraphs 18 and 19) why the estimates of net investment can be accepted with a good deal less reserve, at least so far as errors due to length of life assumptions are concerned.

Acknowledgements

74. In conclusion, I would like to acknowledge the encouragement I have received from Mr. W. A. B. Hopkin, who first suggested that I should undertake this investigation, and from Mr. C. T. Saunders; both have given me much valuable advice during the progress of the study. Though the great bulk of the statistics on which the calculations are based are published statistics, I gratefully acknowledge the help of a number of Government departments and individuals in making available to me unpublished data. I, of course, accept full responsibility for any errors and shortcomings in this paper. Last, but not least, I wish to place on record my thanks to Mrs. J. E. Manley and Miss W. J. Wilkins who have painstakingly carried out a heavy volume of computing work.

Appendix A

The Price Indices

Sources Used for the Price Indices

For the period 1947 to 1953 the indices are those employed in the derivation of Table 45 of the *National Income Blue Book*, 1954; they may be obtained by taking the ratio of corresponding items in Tables 44 and 45. For 1946 and earlier years, the sources of the indices are set out below.

Buses and Trolley Buses

Average ex-factory values per vehicle were worked out from the 1935 and 1948 Censuses of Production and from the 1937 Import Duties Enquiry. This was done separately for six classes of complete vehicle or chassis and the six series of average values were then weighted in proportion to the number of vehicles of each class produced in 1935. An average value index was thus derived linking 1935, 1937 and 1948. The estimates for other years between 1925 and 1939 were then made by extrapolating or interpolating from the 1935 and 1937 figures by reference to an index of commercial vehicle retail prices published by the Society of Motor Manufacturers and Traders (*Motor Industry of Great Britain*, 1939, p. 47). Rough guesses have been added for 1923–1924 and 1940–1946.

Road Goods Vehicles

The method described above for buses cannot be applied to goods vehicles because of differences in the classification of vehicles in the post-war and pre-war censuses. For buses and passenger cars, the indices of average ex-factory value in 1935 were respectively 50 and 49 (1948 = 100). For goods vehicles the corresponding index was therefore assumed to be 50. Indices for the rest of the period 1925 to 1939 were then obtained by extrapolating from the 1935 figure by reference to the Society of Motor Manufacturers and Traders' index of commercial vehicle prices. The index for 1923–1924 and 1940–1946 is largely guesswork.

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Passenger Cars

For linking 1935, 1937 and 1948 a method similar to that described for buses was employed (see above); ten classes of complete car or chassis were distinguished in the calculation. The links between 1935, 1937 and 1948 so obtained relate to ex-factory values, and to translate these into an index of retail prices account has to be taken, in the case of cars, of the incidence of purchase tax in 1948. Estimates for the rest of the period 1923–1939 were obtained by interpolating and extrapolating from the 1935 and 1937 figures by reference to an index of retail prices of passenger cars published by the Society of Motor Manufacturers and Traders. The index for 1940–1946 is mainly guesswork, but changes in the rates of purchase tax have been allowed for.

Railway Rolling Stock

Average values per ton were calculated from the 1935 and 1948 Censuses of Production and from the export statistics for the same two years. These average values were worked out separately for different classes of rolling stock, and the results combined to give an average value index linking 1935 and 1948. The index for 1935 (with 1948 = 100) was 37, the same as for plant and machinery, and I have assumed that the index for plant and machinery was applicable also to railway rolling stock for all years under consideration.

Price Indices, 1839–1918

1948 = 100

	Buildings and Works(1)		*Plant and Machinery*	*Buildings and Works*(1)
1839–1850	21	1885	..	21
1851	20	1886	..	21
1852	19	1887	..	21
1853	20	1888	..	21
1854	21	1889	15	22
1855	21	1890	16	21
1856	22	1891	16	20
1857	21	1892	16	20
1858	22	1893	15	19
1859	22	1894	15	19
1860	21	1895	15	19
1861	20	1896	15	19
1862	20	1897	16	20
1863	21	1898	16	20
1864	21	1899	17	21
1865	21	1900	19	21
1866	22	1901	19	21
1867	22	1902	19	20
1868	24	1903	18	20
1869	22	1904	18	20
1870	22	1905	18	20
1871	22	1906	19	20
1872	22	1907	19	20
1873	23	1908	19	20
1874	24	1909	19	20
1875	23	1910	19	20
1876	24	1911	19	20
1877	24	1912	20	20
1878	24	1913	21	21
1879	23	1914	20	21
1880	24	1915	24	26
1881	23	1916	28	33
1882	22	1917	33	42
1883	22	1918	39	53
1884	22			

(1) Including housing

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Ships

The price indices shown in the table are applicable only to expenditure on newly built ships. The link between 1938 and 1948 is based principally on Fairplay's index for the cost of a 9,500 d.w.t. motor cargo ship (see M. G. Kendall, *J.R. Statist. Soc.*, 1948, p. 142).

The proceeds of sales of second-hand ships to foreign owners in the years 1948 to 1953 (which represent a deduction in arriving at figures of gross investment) have been converted into terms of constant 1948 prices by means other than the use of a price index. The tonnage of each ship sold has been multiplied by the average 1948 replacement cost per ton, and 1/24th has then been deducted for every completed year of age of the ship in order to obtain its estimated "written-down" replacement value at 1948 prices. Estimates of gross investment in the years 1948 to 1953 in terms of 1948 prices have been derived by deducting the aggregate written down replacement value (at 1948 prices) of all ships sold from the estimated value (at 1948 prices) of all newly built ships.

Price Indices, 1919–1953

1948 = 100

	Buses, etc.	*Road Goods Vehicles*	*Passenger Cars*	*Ships*	*Plant and Machinery*	*New Housing*	*Other New Buildings and Works*
1919	..	..	..	..	46	68	64
1920	..	..	..	..	54	78	71
1921	..	..	..	..	60	68	58
1922	..	..	..	..	52	40	45
1923	97	99	90	..	40	41	40
1924	89	91	82	..	39	41	42
1925	78	80	73	..	38	46	42
1926	70	72	70	..	37	46	42
1927	72	74	69	..	37	43	42
1928	66	68	66	..	37	40	41
1929	67	69	58	..	37	38	41
1930	66	68	54	..	37	37	40
1931	62	64	49	..	38	36	38
1932	59	60	44	..	37	34	37
1933	57	59	43	..	37	34	35
1934	54	56	45	..	36	34	36
1935	50	50	38	..	37	33	38
1936	49	49	36	..	38	35	40
1937	50	48	36	..	41	39	42
1938	51	51	37	33	45	38	43
1939	49	49	35	..	47	40	42
1940	53	53	40	..	52	45	45
1941	57	57	54	..	58	50	50
1942	61	62	59	..	64	56	56
1943	66	67	64	..	74	63	63
1944	71	72	69	..	78	71	71
1945	77	78	76	..	78	80	80
1946	83	84	82	..	78	86	86
1947	89	91	89	90	90	94	93
1948	100	100	100	100	100	100	100
1949	99	102	102	108	104	102	102
1950	99	111	104	116	109	105	106
1951	105	132	127	134	120	117	123
1952	114	145	143	155	135	126	133
1953	113	139	130	155	137	126	134

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Aircraft

In the absence of any price index specifically relating to aircraft, the price index for plant and machinery has been used.

Plant and Machinery

The index for years up to 1948 is essentially a measure of changes in average value per ton of specific classes of plant and machinery. The data are obtained from the export and import statistics and, for censual years, from the Censuses of Production and Import Duties Enquiries. The method has been described fully by H. J. D. Cole in the *Bulletin of the Oxford Institute of Statistics* (March 1951 issue), and in fact I have made use of the estimates he gives. Cole's estimates for export and import average values cover the years 1920 to 1939 and also 1947, and, using similar methods, I have extended these figures (for exports only) to cover each year from 1939 to 1948. Similarly Cole's estimates for average values of home-produced machinery cover the censual years 1924, 1930 and 1933 to 1935, and I have again extended the estimates both backwards and forwards to cover the Censuses of Production of 1907 and 1948.

The indices of average value derived from the two alternative sources (i.e. from export and import data and from production data) are in fairly good agreement; taking 1948 = 100 there is only a difference of about one point between the alternative estimates for any of the census years 1924, 1930 and 1933 to 1935.

The methods described cover the years 1907 and 1920 to 1948. The estimates for 1889 to 1914 have been obtained by extrapolating from the 1907 figure by reference to figures of average value of machinery per ton given in A. K. Cairncross's *Home and Foreign Investment*, 1870–1913 (1953), Table 37.

The figures for 1915 to 1919 are guesses.

New Housing and Other New Buildings and Works

A number of indices of building costs have been published in the past. They have been compiled on differing bases, are of varying reliability and cover different periods of years. These indices have been "spliced together" to form the indices used in this paper. Where, for some period of years, alternative published indices were available and there seemed no strong grounds for regarding one of them as more reliable or relevant than the others, a rough average of the indices has been taken.

The following are the published indices from which the indices used in this paper have been compiled. The figures in square brackets indicate the years covered by each index.

(i) G. T. Jones' index of selling prices of buildings (given in his *Increasing Returns* (1932)). [1845–1922.]

(ii) H. J. Venning's estimates of the building cost of single storey factories and working-class flats (published in *The Architect*, January 12th, 1934, and reproduced in an article by Colin Clark in Special Memorandum No. 38 of the London and Cambridge Economic Service (September, 1934)). [1914, 1924, 1929–1930, 1933.]

(iii) Costs per square foot of non-parlour houses for which tenders were received by local authorities in England and Wales (set out in *Private Enterprise Housing* (H.M.S.O., 1944), Appendix V*b*). [1919–1939.]

(iv) Colin Clark, in London and Cambridge Economic Service Special Memorandum No. 38, gives a weighted mean of the prices of specific items of building work (e.g. a rod of brickwork) taken from *The Builder* and *The Illustrated Carpenter and Builder*. [1920–1933.]

(v) *The Economist* worked out an index of building costs by taking an unweighted mean of indices of wage rates and materials prices (reproduced in H. W. Robinson's *Economics of Building* (1939), Appendix 2). [1924–1937.]

(vi) The Girdwood Reports on *The Cost of Housebuilding* (H.M.S.O., 1948, 1950 and 1952) give estimated changes in the cost of a standard 3-bedroom local authority house. [1938–39, 1947, 1949, 1951.]

(vii) *The Report of the Working Party on Building* (H.M.S.O., 1950) gives an index of building

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costs, based on a combination of indices of materials cost, earnings per hour, output per man hour and overheads. [1939 and 1946–1948.]

The published indices which refer specifically to new housing (i.e. (ii), (iii) and (vi) above) have been employed in compiling the index of new housing prices covering the years 1919 onwards which is set out earlier in this Appendix. Before 1919 a single index for both housing and other building work has been used.

Appendix B

I. *Definitions of the Industries;* II. *Lengths of Life Assumed; and* III. *Sources of the Estimates of Gross Fixed Investment*

The industrial classification follows that of the *National Income Blue Book*, 1954, Table 46, except where otherwise noted below. As in the *National Income Blue Book*, vehicles and ships owned by establishments in industries outside transport have been classified so far as possible to the industries owning them and not to the transport industry. An exception is road vehicles employed in agriculture, which are here included under manufacturing and distribution. In consequence about 90 per cent. of all investment in road vehicles (other than buses) appears in this paper under the heading "Manufacturing and Distribution, etc."; the only significant cases of road vehicles (other than buses) classified outside this industry group are vehicles employed in the fuel and power industries, railways, the Post Office and public and social services (e.g. fire and police).

For the years 1948 to 1953, the estimates of gross fixed capital formation given in the *Blue Book*, 1954, Tables 43 to 47 have been used. For earlier years the principal sources are set out below.

Estimates of the value of assets destroyed in the war have (except for houses and shipping) been based on the compensation paid under the War Damage Act, 1943, and the War Damage (Public Utility Undertakings, etc.) Act, 1949. Only complete losses have been taken into account, and this has entailed making an approximate division of compensation between such losses and repairable damage.

1. *Agriculture*

I. The estimates relate to plant and machinery only. Vehicles employed in agriculture are in this paper included under the heading "Manufacturing and Distribution, etc."

II. The lengths of life assumed are those set out in *Agricultural Machinery* (P. E. P. Report 1949), Table 11, column I.

III. Statistics of numbers of different types of machine produced for the home market in the years 1937 onwards have been converted to current value terms by multiplying by the average 1945 values per machine (given in *Agricultural Machinery*, Table 11) and then applying the plant and machinery price index. An addition, based on Trade Statistics, has been made for imports, and the resultant has been employed as an indicator to extrapolate the 1948–1953 estimates of gross investment back through each year to 1937.

Estimates of the ex-factory value of agricultural machinery (excluding parts) produced in the censual years 1924, 1930, 1933–1935 and 1948 have been derived from the Censuses of Production and Import Duties Enquiries. After deducting exports and adding imports, an indicator has been obtained to extrapolate the 1948 figure of gross investment back to 1924, 1930 and 1933–1935. Estimates of gross investment in the intervening years have then been obtained by interpolating the censal year figures by reference to employment in general engineering (production of agricultural machinery at constant prices having been assumed to vary in accordance with this level of employment) and data on exports and imports.

2. *Coal Mining*

I. The estimates relate to plant and machinery and vehicles only, that is excluding mine workings and buildings. Purchases of colliery-owned railway wagons now vested in British Railways have been excluded, and treated as part of the investment of the railway industry.

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II. The lengths of life assumed have been based on the rates of depreciation allowed to collieries by the Inland Revenue,* and are as follows.

Surface machinery or plant, other than electrical	34 years
Electrical plant at the surface and all underground plant installed in the shaft pillar	30 „
Other underground plant	22 „

III. The estimate of gross investment in 1947 is from the National Coal Board's Report. For 1907, 1924, 1930, 1933–1935, 1937 and 1946, the estimates have been derived by extrapolating the 1948 gross investment figure on the basis of data on mining machinery taken from the Censuses of Production and Trade Statistics; the method is similar to that employed for estimating agricultural investment before 1937 (see above), and it relies on the perhaps doubtful assumption that the trend in the intake of general-purpose machinery to coal-mines was the same as the trend of the intake of specialized mining machinery. Estimates for other pre-war years have been obtained by interpolating as for agriculture.

For 1939–1945 the estimates of gross investment were deduced from the year-to-year changes in the depreciation allowed to colliery undertakings by the Inland Revenue. This method is similar to that employed for estimating wartime investment in plant by manufacturing and distribution (see section 13, III (b) of this Appendix).

3. *Gas*

II. The lengths of life have been based on the lives assumed by the Gas Council in calculating depreciation (see their Annual Report for 1950–51 pp. 87–90), and are as follows:

Buildings and works:	
Buildings	50 years
Mains: 75 per cent. of each year's investment in mains has been assumed to have a life of 50 years, and 25 per cent. a life of 30 years	
Consumers' services	10 „
Plant and vehicles:	
Gasholders	50 „
Gas transmission plant	50 per cent. of 40 „
	and 50 per cent. of 30 „
Gas manufacture plant	24 per cent. of 40 „
	24 per cent. of 30 „
	and 52 per cent. of 20 „
Ships	25 „
Meters	15 „
Motor vehicles	10 „
Appliances on hire and prepayment installations	7 „
Furniture, fittings and office machinery	7 „

III. For local authority-owned undertakings the figures of gross investment before 1948 are from the published local authorities' financial returns (see section 15, III). On the basis of Census of Production statistics of output in years from 1924 to 1948 and of census statistics of capital expenditure in 1948 (wherein figures for local authority-owned and company-owned undertakings are given separately), companies' gross investment in the gas industry in each year has been assumed to be exactly twice that of local authorities. The analysis of each year's investment by type of asset has been based on the analysis for post-vesting years shown in the Gas Council's Annual Reports.

4. *Electricity*

II. The lengths of life have been based on the lives assumed by the British Electricity Authority in calculating depreciation (see their Annual Report for 1949–50, Appendix 43), and are as follows:

(*) See the Inland Revenue publication *Income Tax, Wear and Tear Allowances for Machinery or Plant: List of Percentage Rates* (H.M.S.O., 1953).

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Buildings and works	40 years
Plant and vehicles:	
Underground mains	40 ,,
Overhead mains	30 ,,
Plant and machinery generally	25 ,,
Consumers' services	25 ,,
Ships	25 ,,
Consumers' meters	15 ,,
Furniture, fittings and fixtures	10 ,,
Motor vehicles	10 ,,
Office machinery	7 ,,
Apparatus on hire	7 ,,

III. For 1922 to 1947, the estimates of gross investment are the "net" capital expenditure figures given in the annual *Engineering and Financial Statistics* published by the Electricity Commissioners (with a deduction for land and an addition for Northern Ireland). For years before 1922 the series has been extrapolated back, using as an indicator the returns of local authorities' capital expenditure on their electricity undertakings, i.e. assuming local authorities' investment represented a constant proportion of the whole.

5. *Water*

II. Lives of all assets have been assumed to be 75 years. In theory different lengths of life should have been assumed for buildings, civil engineering works, mains and machinery; but such a procedure was not justified here because of the relatively small magnitudes involved and absence of data on the analysis of investment between different types of asset.

III. The figures of gross investment before 1948 were compiled on the same principles as for the gas industry (section 3, III, above). The gross investment of companies in each year was taken to be a fifth of that of local authorities. For 1904 and earlier an approximate adjustment was applied to the published series for local authority capital expenditure to allow for the exclusion therefrom of the undertakings forming the Metropolitan Water Board.

6. *Railways*

I. This item excludes railway-owned docks, canals and hotels, but includes investment in (i) buildings and plant for railway workshops, (ii) railway-owned ships and cartage vehicles, and (iii) privately owned wagons subsequently vested in British Railways. The investment estimates given in this paper exclude renewals of buildings and works which are charged to revenue in the railways' accounts; for this reason the gross investment estimates for 1948–1953 in Table 9 are somewhat less than the figures appearing in Table 46 (item 12) of the *Blue Book*, 1954. If the amount of these renewals is increasing, their exclusion here may result in some overstatement of the extent of net disinvestment.

II. Lengths of life, based except for buildings and works on lives assumed by the British Transport Commission (see their Annual Accounts for 1951, paragraph 55), have been taken to be :

Buildings and works	100 years
Railway rolling stock	30 ,,
Plant	25 ,,
Ships	25 ,,
Road vehicles	10 ,,

III. Estimates of gross investment for years from 1913 to 1947 have been derived from the annual increases in the railways' capital expenditure (as shown, up to 1938, in the Ministry of Transport's annual *Railway Returns*) *plus* the amounts expended annually on complete renewals of railway rolling stock (from the same source). Additions have been made for (i) expenditure on new privately-owned wagons (based on numbers newly licensed each year), (ii) expenditure on London Transport Railways not covered by the *Railway Returns* after mid-1933 (from the London Passenger Transport Board's Accounts) and (iii) some wartime government-financed expenditure. A deduction has been made for purchases of land.

From 1870 to 1912 the estimates have been based on A. K. Cairncross's figures for railway

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capital expenditure (given in *Home and Foreign Investment*, 1870–1913 (1953), Table 26). Cairncross's figures were extrapolated back to 1839 by reference to a smoothed series for the annual additions to the paid-up capital of the railway companies.

7. *Road Passenger Transport*

II. Lengths of life except for buildings have been based on those assumed by the British Transport Commission or implied by the Inland Revenue depreciation allowances; they are:

Buildings	50 years
Plant	25 „
Buses and trolley buses	10 „

III. For vehicles, the estimates of gross investment from 1927 onwards have been derived from statistics of numbers newly registered in each of several categories of vehicle; the numbers have been converted to current prices using average 1948 values per vehicle and multiplying the resultant by a price index. For 1924–1926, statistics of production (quoted in *The Motor Industry of Great Britain*, 1953, which is published by the Society of Motor Manufacturers and Traders) and of exports and imports have been used instead of the registration data.

The estimates of gross investment in plant and buildings are only approximate; they take account of the capital expenditure figures given in the London Passenger Transport Board's Accounts (from 1933 onwards).

8. *Roads*

I. This item covers also public lighting and a small amount of investment by highway authorities in road making plant.

II. The length of life of all assets has been taken to be 75 years. The remarks in section 5, II, of this Appendix apply here also.

III. The estimates of local authorities' gross investment have been derived from their financial returns (as described for other local authority services in section 15, III). Capital expenditure incurred by the Central Government in respect of Trunk Roads (from 1937 onwards) has been added.

9. *Shipping*

I. This item includes all ships apart from fishing vessels and a small number of vessels appearing under other industrial headings (e.g. railways).

II. Lengths of life have been based on depreciation rates granted by the Inland Revenue; they are :

Tankers	20 years
Other ships	25 „

III. Estimates of gross investment in pre-war years have been based on Lloyd's Register figures of tonnage of merchant vessels launched for home registration. To obtain investment at current prices the tonnage launched has been multiplied successively by average 1948 costs per ton and by a price index; allowance has been made for the varying proportion of passenger vessels, dry cargo vessels and tankers in each year's output, since the costs per ton of these three types differ substantially.

Because of the extent of transactions with foreign owners in second-hand ships and of war losses to shipping, the method of computing depreciation illustrated in the table in paragraph 13 of this paper has been considerably modified. The first step in the calculation has been to estimate the gross replacement value at 1948 prices of all ships in the United Kingdom merchant fleet at the end of each year, exclusive of fishing vessels, etc., and exclusive of ships of age 25 years and over (20 years and over in the case of tankers); to do this, reference has been made to the analysis of the fleet by age and type of vessel given in the *Annual Abstract of Statistics* (e.g. 1954 issue, Table 246 (i)). Depreciation in any year (in terms of 1948 prices) has then been calculated as $\frac{1}{25}$th of the gross replacement value at the end of the year ($\frac{1}{20}$th in the case of the tanker component of the fleet). A small addition to the depreciation figures has been made in respect of ships lost or scrapped before expiry of their assumed life (based on tonnage and age of vessels lost and scrapped in each year).

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Net investment at 1948 prices has been derived by deducting depreciation at 1948 prices from gross investment at 1948 prices. Net investment in terms of current prices has then been obtained by multiplying the figures of net investment at constant 1948 prices by the price index shown in Appendix A,

10. *Harbours, Docks and Canals*

II. All assets have been assumed to have lives of 75 years. The remarks in section 5, II, of this Appendix apply here also.

III. For local authority-owned undertakings estimates of gross investment in each year are from the local authority financial returns (as described in section 15, III, of this Appendix); an approximate adjustment to the estimates for years 1909 and earlier has been made to allow for the exclusion from the returns for those years of undertakings forming the Port of London Authority. For railway-owned docks and canals, the estimates are derived in a similar manner to the figures of railway investment (see section 6, III).

11. *Air Transport*

II. The lives of assets set out below have been based on the lengths of life assumed for the purposes of their accounts by the Airways Corporations and the Ministry of Transport and Civil Aviation (the principal civil aerodrome authority); for the latter see *Trading Accounts and Balance Sheets*, 1948–49 (H.M.S.O.), p. 41.

Airways Corporations:	
Buildings and hangars	20 years
Aircraft	Up to 14 „
Operating ground equipment and commercial equipment	8 „
Civil aerodromes:	
Hangars and workshops	45 „
Runways, aprons, etc.	40 „
Other buildings	30 „
Plant and vehicles	15 „

III. In the main the estimates of gross investment before 1948 have been derived from the Airways Corporations' published accounts and the accounts relating to the Ministry of Civil Aviation's aerodromes. I have made no detailed analysis of pre-war investment but have assumed it to be fairly negligible. For years immediately preceding the vesting of the Airways Corporations, rough estimates of gross investment in aircraft, etc., have been based on the book value of assets taken over at vesting date.

12. *Postal and Telephone Communication*

I. The estimates of gross investment given in this paper differ slightly from the figures shown in the *Blue Book*, 1954, Table 46, item 19, owing to the exclusion from the present figures of expenditure on the renewals of certain assets.

II. The lives set out below are based on those assumed by the Post Office in their Commercial Accounts; see 4th Report from the Select Committee on Estimates, Session 1950, p. 122.

Buildings	60 years
Plant:	
Trunk lines	46 „
Local lines and submarine cables	36 „
Exchanges, wireless and postal services	20 „
Subscribers' circuits	7 „

III. The figures for gross investment before 1948 are taken from the Post Office Commercial Accounts and Appropriation Accounts. Expenditure on renewals of equipment (so far as is shown in the Commercial Accounts) has been included. Additions have been made for (i) war plant provided out of Votes of Credit and (ii) estimated capital expenditure on the postal and telegraph services in 1928 and earlier (excluded from the capital expenditure figures in the Commercial Accounts); and a deduction has been made for land. The capital expended on the purchase of the

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National Telephone Company's system in 1911–1913 has been "spread back" over the preceding decade.

13. *Manufacturing and Distribution, etc.*

I. This heading covers a wide range of industries, mainly, but not wholly, in the private sector, namely: mining and quarrying other than coal, manufacturing, building and contracting, road goods transport, broadcasting and distribution and other service industries (i.e. it corresponds to items 5, 6, 8, 14, 20 and 21 of Table 46 of the *Blue Book*, 1954). The estimates omit investment in those factories and plant financed by the Government during the war, which are now *leased* by the Ministry of Supply to private firms. Road vehicles employed in agriculture have been included in this heading.

No analysis between the individual industries comprising the group has been possible Instead, Table 9 gives an analysis by type of asset: namely (i) vehicles (mainly road vehicles), (ii) plant and machinery, (iii) industrial buildings (i.e. buildings used in the manufacturing, building and contracting and mining and quarrying industries), and (iv) commercial buildings (e.g. offices, shops, hotels). The vehicles heading (i) covers about 90 per cent. of all investment in road vehicles (other than buses) in the United Kingdom (see introductory paragraph to this Appendix).

II. The assumed lengths of life, except for commercial buildings and plant for Royal Ordnance Factories, are based on the rates of depreciation allowed by the Inland Revenue for taxation purposes.

Industrial buildings	50 years
Commercial buildings	75 ,,
Road goods vehicles	10 ,,
Passenger cars	10 ,,

Plant and machinery has been divided into five classes with lengths of life of 45, 30, 22, 17 and 14 years; these lives correspond to Inland Revenue basic rates of depreciation on the reducing balance principle of 5, 7½, 10, 12½ and 15 per cent. respectively. It has been assumed that the gross investment of each year after 1944 was subdivided between these five classes in the proportions of 15, 39, 40, 2 and 4 per cent. respectively; and that the gross investment of 1944 and each earlier year was subdivided in the proportions 15, 51, 31, 1 and 2 respectively. These proportions have been worked out by classifying according to depreciation rate the output of machinery as returned in the Censuses of Production of 1935 and 1948 (omitting machinery which is specific to other industries such as coal-mining or agriculture); the depreciation rates are given in the Inland Revenue's publication *Income Tax, Wear and Tear Allowances for Machinery or Plant: List of Percentage Rates* (1953). For plant and machinery in Royal Ordnance Factories, a life of 14 years has been assumed, on the basis of the rates of depreciation employed in the Trading Accounts (see the *Trading Accounts and Balance Sheets*, 1946–47, p. 65).

III(a).—*Vehicles*

Estimates of total gross domestic investment in road goods vehicles and passenger cars have been compiled. A deduction has then been made in respect of vehicles acquired by other industries (e.g. fuel and power industries and the railways) in order to arrive at the investment in "manufacturing and distribution, etc." and a small addition made in respect of railway rolling stock used in private sidings, etc.

Estimates of the total gross domestic investment in road goods vehicles have been derived in a similar way to buses (see section 7, III, of this Appendix). For passenger cars entirely arbitrary assumptions have had to be made, because of the impossibility of distinguishing in the statistics of new registrations between cars bought by businesses and cars bought by consumers, and lack of information on second-hand transactions. I have assumed that in 1946 and 1947 total gross domestic investment in cars equalled half the value of all new cars registered, but that in the war years 1941 to 1945 the proportion was ⅘ths. For each year before 1941, the total gross investment in cars expressed at the prices of 1948 has been assumed to equal half the total gross investment in road goods vehicles (also expressed at 1948 prices); this implies that gross investment in cars in 1939 and earlier years was ⅕th or less of the value of all cars newly registered. (It may be noted

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that figures for cars expressed in terms of 1948 prices contain an element, viz. 25 per cent. of the whole, representing purchase tax.)

III(b).—*Plant and Machinery*

For the censal years 1907, 1924, 1930, 1933–1935, 1937 and 1948 data on production of complete machines, other than those specific to other industries (e.g. agriculture), have been taken from the Census of Production for the mechanical engineering industry. After deducting exports and adding imports a series has been obtained which has been used as an indicator to extrapolate back the 1948 figure of gross investment. Interpolation and extrapolation between 1923 and 1938 has been on the basis of employment in the general engineering industry and export and import statistics.

For projecting the 1923 estimate back each year to 1920, estimates of production of machinery (in terms of constant prices) have been based on figures of consumption of iron products and steel (given by C. T. Saunders, *J. R. Statist. Soc.*, 1952, p. 343), with a deduction for consumption in shipyards.

The estimates of value of machinery retained for home use given by Cairncross (*Home and Foreign Investment*, 1870–1913, Table 37) have been used as an indicator to extrapolate my 1907 figure of gross investment over the period 1894–1914. For the years 1915–1919, rough guesses of gross investment have perforce been made.

From the estimates of investment in machinery and vehicles for years up to 1938, the depreciation allowable for the year 1938 computed according to the rules laid down in the Income Tax Acts has been worked out. The result is in good agreement with the allowances actually granted for that year by the Inland Revenue, so providing a general check on the validity of the estimates of investment for pre-war years.

For the years 1939–1947, the estimates of gross investment in machinery and vehicles in the non-Government part of "manufacturing and distribution, etc." have been deduced from a study of the year-to-year changes in the depreciation allowed by the taxation authorities during this period; the estimate of investment in vehicles (see section 13, III (a)) has then been deducted. In this study of the income tax depreciation allowances, account has been taken of war destruction of equipment (which resulted in reductions in the allowances) and of additional wear-and-tear allowances granted for double-shift working, etc. For the years 1944–1947 the estimates of investment have been based partly on the year-to-year changes in the annual depreciation allowances and partly also on the special "initial allowances" granted by the tax authorities.

Additions for Government investment in the years 1939–1947 in plant for Royal Ordnance Factories have been based on the R.O.F. Trading Accounts and Appropriation Accounts; but of the wartime purchases only plant still employed in R.O.F.s after the war (as shown in the first post-war balance sheet for R.O.F.s, for 1946–47) has been included. (Government equipment declared surplus after the war and sold to private firms before the date of the first post-war balance sheet has been treated in this paper solely as private investment occurring at the date of private purchase and at the price paid by the private purchaser.)

III(c).—*Industrial and Commercial Buildings*

The starting point for the estimates of pre-war gross investment has been the Census of Production returns for the building industry for 1935 and, in the case of industrial buildings, for 1930 also. Additions have been made to the census figures for (i) the output of small firms which did not give any return of output, (ii) the output of trades outside the building industry, and (iii) architects' fees; and deductions have been made for electricity stations and gas works (included in the returns with "factories"). The estimates for the censal years 1930 and 1935 have been interpolated and extrapolated to cover each year from 1864 to 1938 by reference to the following series which have been used as "indicators"; the years for which each series has been used is indicated by square brackets :

(i) The value of plans approved in 146 towns in the categories "Factories and workshops" and "Shops, offices, warehouses and other business premises" (published in the *Ministry of Labour Gazette*, e.g. 1939, p. 46). [1924–1938.]

(ii) The value of plans approved in 78 towns in the same two categories. [1912–1921 linked with 1924.]

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(iii) The annual value of new buildings assessed to Schedule A income tax for the first time in the categories "Factories, warehouses, mills, offices, etc." and "Shops (residential and lock-up), hotels, inns, restaurants and lodging houses, and places of entertainment" [1922–1928.]

(iv) The net increase in the annual value of buildings not charged to Inhabited House Duty in the category "Premises not used as dwellings." This series, which does not distinguish industrial from commercial buildings, has been adjusted in years in which assessments were revised. [1875–1911 linked with 1912–1913.]

(v) Estimates of gross investment in houses (see section 14, III of this Appendix). [1864–1874 linked with later years.]

The ratio of the gross investment series so derived to the annual value series (iii) above gives the "number of years' purchase" of the buildings in question (if adjustment is made for differences in scope between the two series). This provides a general check on the validity of the estimates.

The estimates of gross investment in industrial and commercial buildings in the years 1939–1947 are of very variable reliability; they are based on (i) data collected by the Ministry of Works, (ii) the "partial" Census of Production of 1946, and (iii) information derived from the Trading Accounts and Appropriation Accounts for Royal Ordnance Factories and Government-owned factories in Development Areas. Government ordnance factories built during the war and subsequently disposed of, either to private firms or to the Board of Trade, have been treated in the same way as surplus plant (see section 13, III (b)); in the case of transfers to the Board of Trade, the valuation at transfer has been taken to be the equivalent of the price paid by a private purchaser.

14. *Houses*

I. This heading covers all dwelling houses whatever their ownership.

II. The length of life of permanent houses has been assumed to be 100 years and of temporary prefabricated houses, built just after the last war, 10 years. The national stock of houses in the year 1951 exceeds the estimated numbers built in the preceding century, thus suggesting a length of life in excess of 100 years.

III. For the years 1922–1923 and 1939–1947, gross investment has been estimated by aggregating the investment of the four "sectors" responsible viz. (i) private owners, (ii) local authorities, (iii) public corporations (which have operated extensively in the housing field only since 1939) and (iv) Government departments. The estimates for local authorities have been derived from their financial returns (see section 15, III, below). The public corporations' gross investment has been extracted from their accounts (a deduction being made for land). Expenditure by the Government on the temporary housing programme after the 1939–1945 war has been derived from Government accounts. Finally, gross investment by private owners, and by Government departments on permanent houses, has been calculated, broadly speaking, by multiplying the numbers of houses built for such owners by an estimate of average cost per house (the latter being extrapolated from data on average costs per house in 1924–1938 and 1948 onwards).

For all other years (i.e. 1839 to 1938 excepting 1922 and 1923) a combined total for all "sectors" has been calculated. For 1924 to 1938, the numbers built have been multiplied by the estimated average cost per house; the latter has been taken from the data on building plans approved in 146 towns (given in the *Ministry of Labour Gazette*). The estimates of gross investment for 1924 onwards have been extrapolated back through each year from 1915 to 1921, using as an indicator the series for value of new housing plans approved in 78 towns.

For 1871 to 1914, the figures of numbers of houses built have been taken from Cairncross (*Home and Foreign Investment*, 1870–1913, Table 35). For the period 1831–1870, average rates of house-building in each decade have been estimated from the statistics of numbers of houses given in the Censuses of Population; 25 per cent. has been added to the figures of the inter-censal increases in the number of houses occupied and unoccupied to allow for houses falling out of use. The average cost per house in 1907 has been taken as £250 (a figure quoted by Cairncross (p. 108)) and this has been extrapolated for each year in the period 1839 to 1914 by reference to the index of prices (see Appendix A) and an "index of size and complexity" of houses; the latter, which is given by Cairncross (Table 35), rises linearly from 80 in 1830 to 100 in 1870 and 120 in 1910.

The ratio of the gross investment estimates for 1922 to 1929 to the corresponding figures for

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the annual value of all new houses assessed to Schedule A Income Tax gives the "number of years' purchase" for the houses in question; this provides a general check on the validity of the gross investment estimates.

The estimate of the value of houses destroyed by air raids in the 1939–1945 war has been based on statistics of numbers completely destroyed or damaged beyond repair (given in Cmd. 6707 (1945)).

15. *Public and Social Services*

I. This heading covers the following non-trading services: education (other than privately-owned schools and universities), child care, police and prisons, the fire service, sewerage, arterial drainage and coast protection and other local authority services (items 24, 25, 27–30 and 32 of Table 46 of the *Blue Book*, 1954, except for the private element of item 24). Plant and buildings for the health services and certain other Central Government services are excluded, but vehicles for these services are included.

II. The length of life of all assets (mainly buildings) has been assumed to be 75 years. The remarks in section 5, II, of this Appendix apply here also.

III. The investment included in this heading is almost entirely within the local authority sector. The capital expediture of local authorities, with an analysis by service, is given in the *Local Government Financial Statistics* covering England and Wales and similar publications for Scotland. To arrive at figures of gross investment deductions have been made for (i) purchases of land, (ii) expenditure in connection with small dwellings acquisitions, and (iii) expenditure representing "sums repaid to lenders or transferred to sinking funds out of unexpended balances of loans or other capital receipts". Before 1935, the published figures for England and Wales exclude capital expenditure out of sums transferred from revenue and from special funds; and before 1928 they also exclude capital expenditure out of government grants and other capital receipts (i.e. the published figures before 1928 represent only expenditure out of loans). Approximate additions (on a percentage basis) have been made to the published figures to allow for these omissions. For 1883 and earlier the analysis of loan expenditure by type of service is not, in general, available, and approximate estimates have been made, mainly on the basis of the analysis by type of service of the loan debt outstanding at the end of 1884. Cairncross gives figures of loan expenditure for 1870–1914 in *Home and Foreign Investment*, 1870–1913, pp. 142–145.

16. *Industries and Assets not Covered by the Estimates in Tables 2 to 9*

The industries in question are listed below. References in square brackets are to the items of Table 46 of the *Blue Book*, 1954.

(i) Agricultural buildings [part of 1].
(ii) Forestry and fishing [2, 3].
(iii) Coal industry workings and buildings [part of 4].
(iv) Factories and plant purchased at Government expense during the 1939–1945 war and now *leased* by the Ministry of Supply to private firms [part of 6a].
(v) Ministry of Supply research and development [7].
(vi) Certain assets financed from the revenue account of the British Transport Commission and its predecessors (viz. renewals of buildings and works on the railways) and from the revenue account of the Post Office [parts of 12 and 19].
(vii) The private element of education, i.e. privately-owned schools and universities [part of 24].
(viii) Plant and buildings for the health services [26 except the vehicle component].
(ix) Central Government office buildings, and plant and buildings for certain other Central Government services [31, except the vehicle component].
(x) Legal fees and stamp duties, etc. [34].

In Tables 1 and 10, a rough estimate of depreciation in respect of the assets listed in (i) to (ix) above has been made. In 1948 to 1953 gross investment in these classes of assets averaged 6·7 per cent. of gross investment in all other assets (excluding legal fees, stamp duties, etc.), and this percentage has been assumed to apply also to the depreciation figures for each year.

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Appendix C

Sources of the Published Accounts Figures Reproduced in Table 12

Gas: Annual Reports of the Gas Council. In estimating the net value of fixed assets at the end of 1952, a deduction of £13 million has been made from the figure given in the Accounts in respect of intangible assets taken over at vesting date.

Electricity: Annual Reports of the British Electricity Authority and North of Scotland Hydro-Electric Board. The amounts charged by the N.S.H.E.B. to their revenue account in respect of capital redemption have been treated here as the equivalent of depreciation.

Railways: Annual Reports of the British Transport Commission.

Postal and telephone communication: Commercial Accounts of the Post Office.

In the case of the Gas Council, British Electricity Authority and the Post Office, figures for financial years ended March 31st have been interpolated to give calendar year estimates.

Sources used in Compiling the Statistics of Quantity of Capital in Table 13

1. Agricultural machinery: the figures of numbers of machines in use are from the *Annual Abstract of Statistics*, 1954 issue, Table 198; the average 1945 values per machine are derived from *Agricultural Machinery* (P.E.P. Report, 1949), Table 11.
2. Coal mining machinery in deep mines : *Ministry of Fuel and Power Statistical Digest*, 1953 issue, Table 27.
3. Electricity: *Ministry of Fuel and Power Statistical Digest*, e.g. 1953 issue, Tables 96 and 121.
4. Railway rolling stock: *Annual Abstract of Statistics*, e.g. 1954 issue, Table 234; Annual Reports of the British Transport Commission, e.g. 1953 Accounts, Statements VII.2 to VII.6; pre-war *Railway Returns* published by the Ministry of Transport.
5. Road passenger transport vehicles: *Return of Mechanically Propelled Road Vehicles*, e.g. Return No. 164A gives figures for 1953.
6. Road goods vehicles: Same source as for Road passenger transport vehicles.
7. Ships: Ministry of Transport records.
8. Postal and telephone communication: *Annual Abstract of Statistics*, e.g. 1954 issue, Table 253.

Discussion on Paper by Mr. Redfern

Mr. W. A. B. Hopkin (in proposing the vote of thanks); Mr. Redfern has made a most important contribution to our knowledge of a subject which is both very important and very difficult. As far as the United Kingdon is concerned it is pioneering work, and it is remarkable how much he has been able to achieve.

One might comment on the paper from any of three different aspects: first the fundamental objectives and principles of the study, secondly the statistical methods, and thirdly the conclusions. As regards fundamental objectives I think there is an important distinction between the objective of getting a measure of the national income which makes a proper allowance for capital consumption, and the objective of measuring the growth of the stock of capital as a factor in production. The first objective, that of getting a proper measure of the national income, is an important one and I think Mr. Redfern's methods achieve it in a degree which in an imperfect world can be regarded as satisfactory.

The second fundamental objective, that of measuring the growth of real capital, is even more important: and here I think Mr. Redfern's method has inherent limitations—at least if you believe, as I do, that the most important reason for being interested in the stock of capital is that it has a bearing on the level of national production. His "net stock of capital" concept suffers from a characteristic which from the "national income" point of view is a merit, namely its two-dimensional character, to use the phrase taken by Mr. Redfern from Professor Pigou. His "gross stock of capital" concept is only one-dimensional, but will not approximate closely to the quantity of capital in the economy unless the actual lengths of life of capital assets conform closely to the assumptions made in the paper. In short, Mr. Redfern is measuring the stock of capital in a rather special way, and we have to remember this all the time in using his figures. Only with a good deal of experience can we learn fully how they can rightly be used. I am not suggesting that Mr. Redfern himself is not quite aware of all this; indeed he gives a full account of the reasons why the stock of capital, in either of the two senses in which he defines it for measurement, may not correspond in its movements to the quantity of capital in any sense relevant to current production.

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I think that there is an example of the importance of referring back to fundamental objectives in the treatment of obsolescence. I do not feel entirely happy about Mr. Redfern's treatment on this point, in particular about his insistence on depreciating every kind of capital asset, however durable. At least I think it needs rather more discussion. It is arguable that, at least from the "income measurement" angle, obsolescence due to technical improvements ought not to be treated as a cost in reckoning the national income. From the point of view of measuring the stock of capital, on the other hand, anything that in fact reduces the quantity of capital assets needs to be allowed for, whatever its character, and so a realistic allowance for wastage due to obsolescence can be justified.

On Mr. Redfern's sources and detailed statistical methods I do not want to make more than one quite general comment. There are, no doubt, many weak spots in the mass of data, some of them stretching far back into the relatively unmeasured past, which he has employed. In order to do the job at all Mr. Redfern has had to use many dubious figures and make many questionable assumptions. If he had waited for accurate data on all the relevant points to present themselves he would never have started. To do the job is the best way of improving the data for the next man. In the meantime let us proceed with caution in the application of Mr. Redfern's results, but with a proper sense of gratitude to the man who got them.

I have no time to comment on those results in detail, but will just mention rapidly one or two of their more striking features. Mr. Redfern's figures bring out strikingly the sharp growth in the net stock of capital of manufacturing industry and distribution, etc., since the end of the war: also that this has occurred principally in plant and machinery. The fuel and power industries also show sharp increases, though we must remember the coal figures are for plant and machinery and vehicles only. The stagnation of capital in the transport industry, except for road vehicles, is also very evident. The net stock of capital of the nation as a whole seems to have grown at about 2½ per cent. per annum on average from the beginning of 1948 to the beginning of 1953. The figures are worthy of study in detail and will, I am sure, receive it. Their implications are many and important. I only plead that if they get used in public discussion—and I think it is inevitable that they should be so used—they will be employed with a proper regard for their true meaning, for their margins of error and for their limitations.

Let me then conclude by saying how grateful I think we should all be to Mr. Redfern for the hard thought and hard work that has gone into this paper. We should also be grateful to Mr. Campion and Mr. Saunders for having encouraged this research. I believe this to be one of the most important pieces of work done in the field of economic statistics in this country since the end of the war. In that belief I am happy to propose the vote of thanks.

Mr. R. Glenday (in seconding the vote of thanks): The Society is fortunate in having Mr. Redfern's paper on the Net Investment in Fixed Assets in the United Kingdom at a time when the President's inaugural address on the so-called Macmillan Gap and the Shortage of Risk Capital is still fresh in its mind. Mr. Redfern's paper, as I see it, may be regarded as covering a complementary aspect of the same problem. Lord Piercy, if I understood his purpose aright, was primarily concerned with the availability of funds for certain types of investment. Mr. Redfern's purpose is to show how some of those funds were invested in real resources.

In the background we have the general problem which is comprised in the allegation made by the Chancellor of the Exchequer that the overall investment of industry is insufficient for the needs of a progressive industrial nation operating in a world market of highly competitive manufacture. While that problem is not strictly relevant to the material of Mr. Redfern's paper I do suggest it is vital to the interpretation that is likely to be placed on some of his results.

While industrialists are by no means of one mind as to the justice of this charge, I believe they would all agree that had it not been for certain acts of Government policy in the fields both of taxation and investment since the end of the war there would to-day have been a substantially larger total of private investment in Britain.

On the taxation side, the concession made by the Chancellor of the Exchequer in his last Budget seems a partial admission of the justice of industry's complaint at least so far as depreciation allowance is concerned.

But few seem to be aware of the extent to which post-war Government policy has hampered industry on the material side by preventing it from securing its full share of the real resources which it felt it needed to maintain and improve its efficiency. It is not so long ago that the Government of the day officially approached industry in its corporate capacity asking for its co-operation in putting a brake on investment by private business.

As is well known, the export drive and rearmament also checked the supplies of machinery and plant available for ordinary home investment and there have been restrictions on not only commercial but also on industrial building. It is true that most of these restrictions were subsequently modified, but, unfortunately, planning of investment by the average business man is not

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something capable of year to year control by Government fiat—like turning on and off a bath tap—without danger of causing serious interruption in the ordinary long-run evolution of business activity.

In any event the factors that will govern the behaviour of the average business man are by no means always the same as those that will influence Government planning. In fact, they may quite possibly operate in a contrary direction. Besides, the manner in which the average manufacturer behaves will be affected by such things as changes in the world pattern of industry, the business climate and the needs of the market for which he caters. These are matters which do not normally come within the purview of Government.

Lord Piercy in his Presidential address referred to the effect on the conclusions of the Macmillan Committee of the dramatic changes which were taking place in the organization of the capital issues market during the years which came under its review. It is quite possible, I suggest, that Mr. Redfern may also find in the years to come that he, too, was looking back at the middle of a period of transition so that some of the current conclusions derived from his paper may have to be revised later.

This is in no sense a criticism of his analysis as such nor is it intended to imply that his work has not been an extremely worth while effort. It is in any case to be warmly commended for the light which it throws on the growth of Capital formation in the British economy since the war. Besides, anything that can be done to assist economists, statisticians and indeed the general public to pierce the veil that shrouds the figures provided periodically by the Central Statistical Office deserves, I suggest, every encouragement.

Mr. Redfern is, I consider, particularly to be commended for the modesty and caution with which he has presented his results. He admits the limitations of his data and that there "was probably no perfect statistical solution to the problem posed by the economists". He recognizes most of the principal snags: the difficulty of constructing suitable price indices for products whose character is continually changing, the problem of arriving at suitable writing down values of assets, and last, but by no means least, the impossibility of expressing in any accurate way the concept of "maintaining capital intact".

This third snag seems to me to raise an issue of major importance since the period covered by Mr. Redfern's figures was notable for the incorporation over a wide range of industry of new methods and processes resulting from recent discoveries and inventions whose adoption was held over owing to preoccupation with the needs of the war-time effort.

I agree that Mr. Redfern is aware of this difficulty. He writes, "A worn-out machine is rarely replaced by a precisely identical machine; it may be replaced by a more efficient machine, or because some new process has been invented, the worn-out machine may not be replaced at all". But what did worry me in reading his paper was the concluding sentence of the next paragraph, para. 11, in which he explains that "the figures of net investment appearing in this paper tend to omit increases in productive resources arising not from the increase in the number of assets in use but from an increase in their efficiency". If this means what it seems to mean it is surely a startling attitude to take towards investment figures covering a period notorious for major innovations in the field of efficiency and capital-saving inventions over a wide field.

While I fully understand why it was impracticable for Mr. Redfern to take proper account of this factor I do feel that some of the conclusions likely to be drawn from his results, particularly by the incautious reader, may lead to misunderstandings, for it involves ignoring the basic essential features of a period of transition and innovation when capital formation in Britain was higher than ever before.

Incidentally, it must not be forgotten that this was the same period of transition in which the orderly recovery of industry from the war was being interrupted by largely fortuitous and unpredictable alterations in important sections of Government policy made to meet the special needs of the change-over to peace-time conditions.

In view of this, it is not surprising that certain of Mr. Redfern's tables suggest at first sight disconcerting conclusions. Table 5, for example, implies that the aggregate net capital formation in manufacturing and distribution in 1953 was exactly the same as that in 1938. On the other hand, when we turn to Table 9 in which the aggregate figures are subdivided into four categories we find that what actually happened in the period 1948–53 was that the annual amount of net investment in plant and machinery was on the average 60 per cent. greater than in 1938 and net investment in industrial buildings was up on the average by three or four times, while investment in vehicles on the same basis was more than trebled. The feature mainly responsible for the disturbing deduction drawn from Table 5 was, it appears, the heavy disinvestment in commercial building from + 78 in 1938 to − 12 in 1953, a change for which, if my memory serves me aright, Government investment policy was largely directly responsible.

Another feature of interest is that the peaks of investment in the different sectors during the period occurred at different dates. The peak in vehicles was in 1949, in industrial building in 1950,

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in plant and machinery in 1951. It would be interesting to see what a still further subdivision of those categories would reveal. It would also be useful to examine to what extent it would be feasible to correlate the course of events in the different sectors in these years with known fluctuations in Government policy in these same years, or with prominent changes in the field of industry itself.

Nothing in the above observations is intended to depreciate the worth of Mr. Redfern's paper. I agree with every word that the proposer of the vote of thanks has had to say about it. Mr. Redfern is to be congratulated on having provided the first statistical measure of Britain's investment performance since the war. It is greatly to be hoped that the reception given to this paper will lead the Central Statistical Office to encourage other members of its staff to present this Society with similar papers on its statistical compilations.

It gives me very great pleasure to second the vote of thanks.

The vote of thanks was put to the meeting and carried unanimously.

Mr. J. STAFFORD: It is a very great pleasure indeed to associate myself with what Mr. Hopkin and Mr. Glenday have said about this paper. It is a most important paper and one that represents a great deal of hard and original work. The information and estimates in the tables will be of very great use and interest to people both inside and outside the Government service.

In the paper Mr. Redfern goes out of his way to indicate some of the conceptual difficulties he has had to face in making these various estimates. I am sure, therefore, he is very aware of these difficulties; but because they are so important I should like to say something about them and perhaps pose them in a rather different fashion.

The first difficulty, I expect, is to be found in answering the major question of whether it is wise to attempt a measurement of net income or of net investment. There is one simple way of measuring net income (and net investment); and there are other, more complicated, ways which involve one in all kinds of problems. The simple way is to regard investment as an immediate cost, like the purchase of other factors of production, and to write it off as it is incurred, so that no part of investment is brought into the concept of net income. Or one can abandon the concept of net investment and rest content with the identification of gross investment and gross income.

Perhaps there is something to be said for that simple alternative when one is concerned with the measurement of national income. There is less to be said for it if one is dealing with the practical affairs of business and the striking of profits.

From the standpoint of a community, the difficulties of determining how to bring depreciation into account can perhaps be illustrated by a very simple kind of example. Suppose that an individual put up a toll-bridge at the cost of £100 and a decision was made that the bridge was likely to last 100 years and should be depreciated at, say, £1 per year. After 50 years the river dries up, the bridge becomes unnecessary and obsolete and no one pays the toll. If the owner of the bridge or the statistician has been depreciating at £1 a year there is still £50 undepreciated. Should this be an obsolescence charge on the community income? Or should the accounting recognize that the community is better and not worse off when the bridge becomes obsolete?

The other difficulty, of course, is the conceptual one to which Mr. Redfern also refers. If we introduce the problem of the price level at the time the bridge becomes obsolete, what amount should be allowed for obsolescence if the cost of the replacement is "different" from the original cost? Is there any real economic reason for posing the question, "What is half the present cost of building the bridge which is no longer required?" and striking that as an obsolescence charge? Would it not be just as meaningful to say that 50 years ago the next most remunerative project was putting down cucumber frames and the correct thing to do, therefore, at the end of the 50th year, is to measure half the cost of replacing the cucumber frames that were not installed? That would give, I think, conceptually as good an answer.

These are the theoretical niceties and the kind of thing which perhaps should guide the statistician dealing with national aggregates. When you come down to more mundane matters you are faced with more compelling difficulties of making decisions about these matters which will help to clarify the situation of an individual business. The business community does demand some kind of answer to the question "What is the proper depreciation allowance and should it be based upon the cost of replacement?"

Mr. Redfern, I think, says in effect that the depreciation allowance should be based upon replacing the same kind of thing, so that the depreciation allowance for buses should be computed according to the movement in the price of buses, and for a locomotive according to the movement in the price of locomotives. I wonder if that is the right solution for the business community. Necessarily over a period of years the prices of capital equipment will move variously. Some equipment will become comparatively expensive to replace and there seems perhaps no very good

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reason why the depreciation allowances on these particular things should be geared to the differentially increasing cost of replacing them. Some wider concept of replacement cost and some more general index of prices are required. But I have no helpful suggestion to put forward on the form which these might take.

Mr. H. C. COTTRELL: The only point of detail which I raise is the problem of fire losses which have been set off in the paper against some of the other imponderables or unassessables. One would have thought that the fire offices could give a little more information on that point. Total fire losses covering both capital equipment and consumption goods are not published, but one would hope that with sufficient pressure the fire offices might be co-operative.

Turning to the implications of the tables, I feel that the comparison of the contribution to gross national product with gross existing capital is less satisfactory than a comparison of net capital with the contribution to the net national product, that is, after deducting depreciation in each case.

Using Mr. Redfern's paper and the *Blue Book* I compared the capital equipment needed in various industrial groups to produce £100 m. of net product a year. In gas, electricity and water £1,100 m. is needed, in transport and communications £430 m., and in manufacturing and distribution only £75 m.

As to labour, to produce the same £100 m. of net national product one needs 207,000 workers in gas, electricity and water, 206,000 workers in the transport and communications industries and only 150,000 workers in manufacturing and distribution.

It seems, therefore, that in order to obtain a given level of net national product it is far better to devote one's resources to the transport and the manufacturing industries rather than to the first group of industries.

One can, therefore, question whether it has been right to devote over £700 m. of new gross capital to the electricity industry since the war, when the return is likely to be so low compared with other industries. It may be, of course, that the pricing of electricity is wrong. It may be that what is really needed is the differential off-peak rate for electricity to encourage industry to have more 24-hour working, so that the electricity industry would not be compelled to install capacity to cope with a peak load twice a day and work at rather a lower level during the night.

To raise the net capital in the transport industry to the level of 1938 would apparently take something like £550 m. of capital, at current prices. To increase the capital in the transport industry by the same proportion as manufacturing industry's capital has increased since 1938 would apparently take about £1,600 m. at current prices. Even this would only be adequate if one accepted that the transport industry had adequate capital in 1938—a proposition which few would accept.

Net fixed capital in railways fell from £1,758 m. to £1,358 m. between 1938 and 1953 despite the fact that freights carried had increased by 30 per cent. Passenger journeys were slightly lower over the same period, there being a little less than a 10 per cent. fall.

It seems quite obvious on these figures that Mr. Redfern has underlined very strongly the hopeless condition of the transport and communications industries at the moment. There is, however, some difficulty in that if we increase the net capital of the transport industry and improve roads there is no obvious income. One reduces the costs of industry, but nowhere is there a figure of which we can say, "This is the national income produced by having a better road".

Looking to the future, I believe that the analysis by types of assets and by broad groups of industries will prove to be inadequate. In order to make policy one will need more detail, which will in turn lead to improved techniques in their interpretation.

The Government in this country must do some planning, and if the purpose of planning is to ensure that such resources as we have are used to the greatest advantage of all, to raise our standard of living, then the people who are taking the planning decisions must have the raw material upon which they can work and a very much more advanced version of Mr. Redfern's approach will be a great help.

Mr. H. G. CLARKE: I have listened to Mr. Redfern this evening with considerable interest because few of us would deny that if reliable estimates of the rate of net capital formation could be made they would provide a most important guide to our national economic progress. The main purpose of our discussion must surely be therefore to examine the author's methods with a view to assessing what degree of reliability can be attached to his results.

In fairness to the author we must admit that he has been at pains to point out the limitations attaching to his methods and thereby the qualifications and deficiencies attaching to his results. In one important aspect however he imputes a deficiency to his figures which in my view does not apply, at least to anything like the extent which he appears to believe. I refer to his statement that the figures of net investment appearing in his paper tend to omit increases in productive capacity arising from improvements in efficiency and design, and the main purpose of my remarks is to endeavour to reassure him somewhat on this point.

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It is generally accepted that the value of an investment at any point of time is based on the present value of the future income expected to be derived from that investment. In the same way the value of a fixed capital asset must be based on the present value of the output expected to be derived from that asset. Thus in building up a figure of capital formation, the values of the assets included in that figure should be such values as reflect the output expected to be derived from them in the future. In other words, and citing the author's own example, if a new machine is designed and produced which gives an output 50 per cent. greater than an old machine, then (*a*) provided the expected lives of the two machines are equal and (*b*) provided the other costs of operation are the same, the value of the new type machines incorporated in a capital formation figure should, in my opinion, be 1·5 times the value of the old.

Mr. Redfern takes the view that the price indices he has employed reflect changes in the quantity of factors of production employed rather than changes in productive capacity. I do not agree with this view, in fact I cannot conceive of a unit of factors of production other than in the form of such unit having a given productive capacity. The factors of production required to make one new machine may appear to be the same quantitatively as those required to make one old machine, but qualitatively they must be different, the former displaying greater efficiency and technical ability. They do not therefore represent identical units of factors of production and can only be related through their productive capacities, which indeed will, in the long run, determine their relative ultimate rewards.

If the price at which the new and more efficient machine is sold is one and a half times the selling price of the old machine, then it will have been incorporated in the capital formation figure at its correct value. Furthermore, if the new machine is sold at this price then, on the provisos I have made above, there would in theory be no inducement to manufacturers to scrap existing old machines before the termination of their useful life in order to replace them with new machines. Thus so long as his depreciation allowances are correct the author's figure for net capital formation will be correct.

We must next examine what we believe happens in practice. In the long run the workings of a free economy will, I think, result in the new machine being ultimately priced at one and a half times the old machine, but the firm which has developed the new and more efficient machine will be unlikely at the outset to charge as much as this, as it will have its eye on the possibilities of expanding its sales and output at the expense of other firms still producing the old type of machine. If the new machine is priced at something less than one and a half times the old there will be an inducement to manufacturers at some stage to scrap existing old machines before their normal life has expired and substitute new machines. In this event two things will happen to Mr. Redfern's figures. In the first place the value at which he includes the new machines in his gross capital formation figure will be lower than it should be. On the other hand the depreciation he allows in respect of the old machines will also be lower than it should be. These two discrepancies tend to cancel each other out when one is subtracted from the other to arrive at the figure for net capital formation. I do not suggest that the two discrepancies will exactly compensate, but at least it must be true to say that the resulting figure for net capital formation does reflect in some measure the results of technical improvements and increased efficiency. I believe therefore that Mr. Redfern has done his own figures some injustice when he says that they tend to omit the effects of such developments.

Whilst I hope that what I have said may be reassuring to Mr. Redfern on this particular aspect of his problem, nevertheless I hasten to add that there are other difficulties involved of such magnitude that the figures which he has produced must be treated with great caution. In order to measure the annual rate of net capital formation accurately we require an annual valuation of existing capital assets, such valuations being based on expected future productive capacity. I admit that such valuations will probably never be practical, but to build up the answer from figures of gross annual capital formation and depreciation allowances based on assumed lives could be very wide of the mark. Not only is there some doubt about the values at which capital formation is recorded and considerable doubt about the assumed lives, but this method takes no account of the fact that there will be "good" and "bad" capital investments.

This, however, should not be allowed to detract unduly from the merit of the task which the author has carried out. By doing the best possible with the very inadequate data at his disposal and promoting a discussion of the limitations and deficiencies of the results thereby obtained, the author has surely done something to encourage the recording of statistics in the future which may give a more reliable picture of the country's net capital formation.

Mr. C. T. Saunders: I should like to add my tribute to those that have already been offered for this highly individual piece of work, which I can imagine few other people undertaking or carrying through.

The best way of testing a new set of data is to try to use it, preferably for some illegitimate

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purpose. One purpose for which a lot of people are going to try to use the figures is to derive relationships between changes in capital stock and changes in output.

This has been done in the United States and has produced an extremely interesting result. A very similar calculation* to that of Mr. Redfern has been compared with changes in output and has shown a quite remarkable fact—a consistent fall in the net value at constant prices of capital per unit of output in manufacturing industry over the past twenty or thirty years. At first sight it appears that much the same conclusion can be drawn about the United Kingdom.

The first fact to take into account, however, is that the degree of utilization of plant was obviously very much less in 1938 than it is to-day; to get a comparable degree of full employment of plant you must add on a percentage to the output figure of 1938. One then gets somewhere near a constant capital-output ratio.

The next thing one wants to examine is the rise in the capital-output ratio during post-war years, which is rather striking from 1949 onwards. How far is this due to the fact that the capital assets of to-day are on average newer than the capital assets of 1949? As Mr. Redfern points out, it would be wrong to take these changes in assets as representing changes in productive capacity.

One notices, looking at the short-term changes, the comparative steadiness with which the rise in assets goes on. A particularly striking case is 1952, when output fell but the amount of gross investment continued to rise. It is only, presumably, the long-term changes that one can reasonably compare.

Clearly, as other speakers have said, more work needs to be done in the breakdown of these changes in capital assets, but, as I understand it, it would probably need a very different kind of approach from that which Mr. Redfern has adopted—probably on the lines of that indicated by Mr. Hopkin, rather than an approach based on data from the census of production, etc., which can be dealt with only in the broadest groups.

Mr. T. K. GRIBBIN: There is a point which I feel will be of some importance in the discussion which this paper will arouse outside. Mr. Redfern has outlined the limitations of his methods and results so well that, perversely, these limitations will be disregarded in public discussion which involves the use of these figures. It is paragraph 47 which I feel will be most quoted in public discussion, the section which says, "As a result of the reduced rate of investment during the war and of war losses, the net value of fixed assets at the end of 1947 appears to have been over £1,000 million—or 5 per cent.—below the level of 1938 (in terms of constant prices)".

It is well known that one does get different results when one works out indices of quantity and price changes with different weights, and as the change here is so small, 5 per cent. for the 1947–38 comparison, I wonder what kind of result we should have got for this comparison if it had been also calculated in terms of 1938 prices.

The PRESIDENT: I should like to say that to my mind this paper is a most impressive performance. We realize that the results must be handled with caution, but the mere statistical results are very interesting and they are distinctly instructive. The only theoretical challenge which came to-night was that of Mr. Stafford, and if time permitted I should like to have broken a small lance with him. However, we have all enjoyed this paper and the discussion, and I shall now ask Mr. Redfern if he wishes to say anything on any point, though he will have the opportunity to deal at length with the various contributions that have been made, in the *Journal*.

The following contribution was received in writing after the meeting:

Mr. R. E. BEALES: In paragraph 7 of his paper Mr. Redfern refers to the alternative methods—"straight line" and "reducing balance"—of calculating depreciation. I would not disagree with his decision to use the "straight line" method in the case of assets, such as buildings, with a very long life, but I think there are points in favour of the "reducing balance" method for plant and machinery. "Wear and tear" allowances for plant and machinery were first recognized in the income tax legislation in 1878 although for a number of years before some bodies of General Commissioners had conceded claims by individual taxpayers for such allowances. It is difficult to believe that at that stage the use of a "reducing balance" method was anything other than the acceptance of recognized accountancy practice. The second point is referred to briefly in paragraph 9 of Mr. Redfern's paper, namely the test of the second-hand prices obtainable in stable conditions. Unfortunately it is difficult to find any goods at present for which there is a sufficiently large second-hand market unaffected by other factors. In the pre-war period, however, there was such a market for passenger cars, and second-hand prices undoubtedly followed a course which was much closer to a "reducing balance" basis than to "straight-line". If gross investment remained

* *Capital and Output Trends in Manufacturing Industries*, 1880–1948. By David Creamer. National Bureau of Economic Research. Occasional Papers, No. 41, 1954.

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unchanged over a sufficiently long period there would, of course, be no difference between the results under the two methods, but with gross investment in plant and machinery for manufacturing industry now at a rate nearly double that of the inter-war years reducing balance allowances would be appreciably higher than the straight-line figures, with net investment correspondingly lower. It would be most interesting if Mr. Redfern could tell us just what the effect of such a change in his assumptions would be—it is not possible to work it out from the figures given in the paper since he has not published his estimates of gross investment for the years 1939–1947.

Two of the speakers in the discussion suggested that a comparison of Mr. Redfern's figures with those on page 88 of the latest National Income *Blue Book* supported the contention that the depreciation allowances given for tax purposes were inadequate. If, however, the two sets of figures are rearranged to cover, as far as possible, the same classes of asset and the initial allowances (now replaced by investment allowances) are taken into account, this is very far from being the case. The figures are as follows:

£ million

	1948	*1949*	*1950*	*1951*	*1952*	*1953*
Mr. Redfern's figures:—						
Manufacturing, distribution, etc. (Table 1)	293	318	352	423	495	516
Water (Table 9)	18	19	19	23	25	26
Road passenger transport (Table 9)	16	18	20	25	28	29
Shipping (Table 9)	43	46	51	55	53	70
Totals	370	401	442	526	601	641
Blue Book (Inland Revenue) figures:—						
Professions	6	8	9	9	6	7
Other sole traders and partnerships (except farmers) Initial	12	20	23	28	12	14
Other sole traders and partnerships (except farmers) Annual	28	29	28	26	26	29
Companies Initial	94	182	231	255	132	136
Companies Annual	208	222	242	246	270	350
Totals	348	461	533	564	446	536

Mr. Redfern's figures include, and the Inland Revenue figures exclude, the depreciation of the nationalized portions of the road passenger, road goods, and iron and steel industries and of the transport and water undertakings of local authorities. If allowance is made for this it appears that for 1948 the two figures were approximately equal, for 1949–1951 the Inland Revenue allowances were substantially higher and that only for 1952 and 1953, when initial allowances operated for part of the year only, were Inland Revenue allowances lower. This is in spite of the fact that Mr. Redfern's figures include allowances, ranging from £40 m. to £55 m., in respect of commercial buildings for which no allowances are given for tax purposes. It may well be that the position would be changed appreciably if Mr. Redfern's figures were recalculated on a "reducing balance" basis and this is perhaps a further reason for suggesting that this should be done.

Mr. REDFERN subsequently replied in writing as follows: Mr. Hopkin has emphasized the different objectives one may have in attempting to measure capital consumption: (i) the estimation of national income, and (ii) the measurement of the growth of capital stock. He suggests that there may be a difference in the treatment of obsolescence according to which of the two objectives one chooses, and Mr. Stafford's fascinating example of the toll bridge raises just this problem. From the point of view of measuring the stock of capital, it is necessary to eliminate the half-depreciated toll bridge from the figures of capital stock, so justifying an obsolescence charge of £50 at the end of the 50th year. Mr. Hopkin, I think, agrees with me on this. In practice, because the fact that the toll bridge had fallen into disuse after 50 years' service was unknown to me, I should have continued to depreciate the bridge at £1 per annum for 50 years after the date it fell into disuse.

But both Mr. Hopkin and Mr. Stafford seem to doubt whether one should adopt the same procedure if the problem is considered from the income measurement angle. I would argue that one should adopt the same procedure, at least if one is considering the *aggregate* income arising from the bridge during its whole life. For the total cost of the asset must be charged as an operating expense at some time or other. But if one is considering the income in the year in which the river dries up *in isolation* from the income in other years, then I agree that no allowance for obsolescence seems called for.

This line of argument can, I believe, be sustained irrespective of the reason for the bridge falling into disuse: the river might have dried up, the construction of a tunnel might have reduced the road traffic to nil, or the structure might have worn out prematurely and collapsed. Indeed it

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does not seem to me part of the job of the national income statistician to try to distinguish between the factors contributing to the bridge's disuse.

Mr. Glenday and Mr. Clarke have commented on the statement (at the end of paragraph 11) that "the figures of net investment appearing in this paper tend to omit increases in productive resources arising not from the increase in number of assets in use but from an increase in their efficiency." Both these speakers implied that the estimates of stock of capital should ideally give some sort of measure of the productive capacity. It is however arguable that what is more important and interesting is a measure of the quantity of factors of production incorporated in a capital asset (i.e. a measure of the "inputs" into, or cost of production of, a capital asset, rather than its potential output).

I will put forward two reasons for this statement. In the first place not every capital asset can be measured solely in terms of its productive capacity, in any sensible way. How is the productive capacity of a public garden or a sea defence work to be measured? And are we to say that Euston Station minus its Doric Arch would be the equal of the station with its Arch because both could handle x passengers per hour—to take an example from industry?

The second reason is perhaps more important. Suppose first of all that the quantity of capital is measured solely by output capacity; for example the capital embodied in an electricity generating plant would be proportional to the number of units of electricity which it could generate per hour. Then so long as capital equipment was fully employed the index of quantity of capital would move identically with the index of output. The ratio of capital to output would vary only on account of changes in the hours worked per week. This would throw very little new light on the growth of capital and its changing importance as a factor of production. Again, if a new machine were installed in substitution for an old machine scrapped, and the new machine gave the same (gross) output as the old machine but with fewer inputs (e.g. if it required less labour, or consumed less raw materials), the proposed method would show capital as constant. But it would be more realistic to regard the constant gross output as the resultant of less labour being combined with *more* capital. This suggests that another method of measuring the quantity of capital would be in terms, not of its gross output capacity, but of its *net* output capacity. Thus the net output capacity of the electricity generator would be its output capacity (in units of electricity per hour) *less* a deduction for other factors of production contributing to that gross output (i.e. costs in real terms of labour, fuel, management and so on). This solution would seem to have many merits were it not for the fact that it is impossible to disentangle the respective contributions to gross output of (a) the capital asset and (b) management and enterprise. In other words, we can treat either profits or depreciation as the residual in the operating account, but the two of them cannot each be derived by this method.

These considerations suggest therefore that the only method of measuring quantity of capital which is both useful and feasible is in terms of its cost of production; this is, broadly, the method followed in my paper. When this method is followed, a new machine of improved design installed in place of an old machine is regarded as embodying more capital only if it costs more (in real terms) than the old machine—which is not always the case. I should add that the arguments set out in the preceding paragraph have been developed at length by E. F. Denison in a paper "Quality Change, Capital Consumption, and Net Capital Formation".*

Mr. Cottrell suggested that statistics of actual fire losses should be taken into account in the calculation of depreciation. I doubt however whether the additional complication involved in this refinement would be worth while, since annual destruction by fire is equivalent to only about 2 per cent. of annual depreciation.

Mr. Cottrell also suggested that a comparison of the *net* capital employed in an industry with its contribution to *net* national product was preferable to the comparison (given in Table 11) of gross capital with contribution to gross national product. I chose to make my comparisons in terms of the gross capital employed in each industry, because this concept is (in theory) not a function of the age composition of assets and is therefore probably more closely related to output than is net capital. (Though I have to admit that the estimates of gross capital in this paper are particularly liable to error.) Whilst the contribution of an industry to gross national product is "inflated" by the depreciation element, yet contribution to net national product can also be misleading in some cases. In fact in a world of imperfect competition, the social "return" of an industry, or of a piece of capital, cannot be measured simply by its contribution to either net or gross national product.

Mr. Cottrell commented on the decrease in the net capital of railways between 1938 and 1953. It is especially important in a case like this to remember that the concept of net capital takes into account the age of assets as well as the quantity of assets, and that a reduction in net capital does not, of itself, imply a reduction in the quantity of assets or in the railways' passenger and freight-

* Paper read at the American Conference on Research in Income and Wealth, October 9–11, 1953.

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carrying capacities. Nor in this case do the figures of gross capital throw much light on the quantity of assets in use, because of errors introduced by the assumptions on lengths of life. (A life of 100 years has been assumed for railway works and buildings, but this is obviously too short a life for many of these assets.) Incidentally the number of passenger-miles on British Railways, which shows an *increase* of about 10 per cent. between 1938 and 1953, is perhaps a better indicator of the volume of passenger traffic than the number of passenger journeys quoted by Mr. Cottrell.

Mr. Saunders mentioned the subject of changes in capital to output ratios, on which interesting conclusions have been reached in the United States. I agree that no firm conclusions for the United Kingdom can be drawn from the results contained in the present paper—partly, no doubt, because of the relatively short period of years covered by the data in this paper, and partly because it is difficult to assess how much of the change in net value of assets between (say) 1938 and 1953 is due to a changed age composition. If satisfactory estimates of the gross value of assets could be derived by the methods set out in this paper, it might be preferable to study changes in the ratio of gross capital to output rather than the ratio of net capital to output.

Mr. Gribbin asked whether the percentage reduction in the net value of assets between 1938 and 1947, in terms of constant prices would have been different if the comparison had been calculated in terms of 1938 prices rather than 1948 prices. Since the meeting Mr. Gribbin has performed this calculation and shown that the reduction works out to almost identically the same percentage whichever set of prices is used.

Mr. Beales has advanced various reasons for using the "reducing balance" formula for writing off assets. It is true that the reducing balance system is used in accountancy, but this of itself does not constitute a good reason for its use in the present context. Moreover the straight line system is also used widely in accountancy, for example by most, if not all, the public corporations. Nor do I think that the evidence of the second-hand market in cars can be regarded as a significant pointer in favour of the reducing balance principle. If the second-hand price of a car falls as much in the first (say) three years of its life as in the whole of the remainder of its life, part of this fall is probably a reflection of changes in fashions, and of the supposed prestige attaching to ownership of a new car. And such considerations do not apply to the majority of capital assets.

A more important reason for adopting the reducing balance principle—and one which Mr. Beales did not mention—is that the cost of maintenance of an asset tends to increase as the asset ages. In other words, its *net* contribution to output tends to fall as its age increases. This can be allowed for by assuming a higher level of depreciation in the early years of an asset's life than in its later years. Without data to show the extent to which maintenance costs do in practice increase with age of asset, it is difficult to judge how far the argument I gave in paragraph 7 for adopting the straight line basis is invalidated: this argument was that "in a great number of cases the productive services rendered by an asset are likely to be more nearly constant over time than to reduce exponentially."

To illustrate how different the results would be if the reducing balance formula had been used, I have computed the estimates shown below.*

Depreciation of Plant and Machinery in Manufacturing and Distribution, etc.

	Straight Line Formula	*Reducing Balance Formula*
		£ *million*
At original cost:		
1948	85	112
1949	95	132
1950	108	155
1951	124	185
1952	142	216
1953	161	241
At the replacement cost of each year:		
1948	161	175
1949	176	195
1950	193	221
1951	224	265
1952	265	318
1953	282	338

* For this purpose the "basic" percentage rate of depreciation (on the reducing balance principle) has been chosen for each class of asset in such a way that 90 per cent. of each asset has been written off by the end of its assumed length of life. The allowances computed by application of this "basic" rate have then been increased by 1/9th, in order to write off the whole (and not just 90 per cent.) of the cost of the asset by the end of its assumed life.

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Because of the higher level of post-war investment as compared with pre-war (in terms of constant prices), depreciation at the replacement cost of each year for plant in manufacturing and distribution is higher for the years 1948 to 1953 if calculated on the reducing balance formula than if calculated on the straight line formula. The reducing balance formula works out at between 8 and 20 per cent. higher. It will also be noted that the ratio of replacement cost depreciation to original cost depreciation is less on the reducing balance rule (between 1·40 and 1·56) than on the straight line rule (where the ratio is between 1·75 and 1·89). The reason for this is stated in paragraph 68.

Mr. Beales includes in his contribution a table showing depreciation at replacement cost for what are, broadly speaking, fixed assets owned by companies and persons, other than farm assets and houses. Certain adjustments to the figures he gives must be made in order to derive estimates for the companies and persons sectors. He mentions nationalized road transport and iron and steel, but certain other adjustments are required, e.g. the elimination of the local authority component of water and road passenger transport, the elimination of Government-owned manufacturing facilities, and the addition of company-owned gas and electricity undertakings before the date of nationalization.

The following table gives an approximate sector analysis of the total depreciation shown in Table 1. The sectors are defined in the same way as in the National Income Blue Books.

Depreciation by Sector, at the Replacement Cost of each year

£ *million*

	Persons	*Companies*	*Public Corporations*	*Central Government*	*Local Authorities*	*Total*
1938 . .	92	185	5	17	62	361
1948 . .	251	310	136	79	125	901
1949 . .	262	320	173	89	115	959
1950 . .	278	348	189	95	126	1,036
1951 . .	318	389	243	106	146	1,202
1952 . .	338	445	278	123	162	1,346
1953 . .	340	478	287	130	172	1,407

The figures shown for persons include depreciation on houses, agricultural machinery and farm buildings, very rough allowances for private non-profit making institutions such as universities, and allowances for legal fees and stamp duties (assumed to be written off in the year in which the expenditure was incurred). These figures for persons cannot therefore be compared with the Inland Revenue allowances for professional persons and other sole traders and partnerships given by Mr. Beales. But the companies' figures shown above may be compared with the Inland Revenue allowances for companies quoted by Mr. Beales; though, as he mentions, the Inland Revenue figures contain nothing for commercial buildings on which no tax allowance is given.

From the sector analysis of depreciation given above and the sector analysis of gross fixed investment in Table 43 of the National Income Blue Book of 1954, it is possible to derive a sector analysis of net fixed investment. The resultant negative figures of net investment by persons in 1948 to 1952 are the result of the low rate of privately-financed house building in those years.

As a result of the ballot taken during the meeting, the candidates named below were elected Fellows of the Society:

Dev Raj Bhatia.
Richard Ian Cole.
Homi Pestonji Dalal.
Pramatha Chandra Datta.
John Lunn Douglas.
David Evans.
Gordon Forsyth.
Norman Willis Fox.
Sigbert J. Prais.
Maurice Seymour Rothera.
Brian John Stops.
John Raymond Turcan.
Bernard Roy West.

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A Discussion on the Teaching of Mathematical Statistics at University Level

Opened by Professor E. S. Pearson, Dr. J. Wishart, Professor G. A. Barnard, Professor M. S. Bartlett, Professor D. G. Champernowne, Dr. D. J. Finney

[Held before the Royal Statistical Society on Wednesday, February 16th, 1955, the President, Lord Piercy, C.B.E., in the Chair]

Professor E. S. Pearson (University College, London):

In opening this discussion I have had the advantage of reading the views of the five main speakers before having to commit my own words to print. After turning over their contributions in my mind, it seems to me that it would be useful to lead off with some remarks on the question of what we mean by the phrase "mathematical statistics". In the Council's Memorandum on Official Statistics (*J.R. Statist. Soc.*, 1943, **106**, p. 147) a distinction was drawn between the categories of *Descriptive Statistics* and *Mathematical Statistics*. Some of us were not quite happy at the time with this dual classification, but I have since become more ready to accept the terms by introducing in my own mind yet another category, that of *Statistical Mathematics*. It may help us in this discussion if the two terms, Mathematical Statistics and Statistical Mathematics are kept in mind.

As I see it, mathematical statistics is a form of application of mathematics, which has this special characteristic; to use Professor Kendall's words, "we are concerned not only with the relationship of theory with the external world but also with the relationship between our calculus and the way we think". Thus the student must not only be encouraged to acquire a critical attitude of mind, always ready to question whether the orthodox mathematical model does in fact represent the situation with which he is faced; he must also learn to think about the meaning of the probability measures which he uses, and about their relation to common processes of rational thought. The ideas which are here involved may be quite easily introduced with the aid of mathematical techniques far less advanced than those required to cope, for example, with the course for students taking paper (j) in the Oxford Diploma (see p. 212, Appendix 4(a)). The difference, I would suggest, is that in one case we are concerned with teaching Mathematical Statistics, in the other Statistical Mathematics.

Be that as it may, I am sure that we all agree that the problem with which we are constantly faced as teachers is how best to combine, and in what order, the twin elements of mathematics and statistics. In London, as Professor Barnard will point out, we have considerable variety in the teaching schemes in operation. The London School of Economics and University College teach mathematical statistics on a large scale, both as regards total teaching hours and number of students, and in both places this teaching is carried on independently of any department of mathematics. Thus many of the difficulties which the speakers who follow will refer to are not encountered at these two institutions.

Appendix I (p. 207) sets out our general programme of teaching at University College. I will only refer to two points; one concerns the nature of our courses, the other is a comment based on recent post-war experience.

Most of our courses involve a very considerable amount of time spent on practical or class work in the statistical laboratory. We do not regard these hours as merely for training in computing, although it is good that the student should learn not to be afraid of computation. What we try to do in addition, often with the help of experimental sampling, is to drive home some of the ideas introduced in lectures; to show how the models work and how unexpectedly good some approximations are; to illustrate sampling variation, the distributions of alternative estimators, the meaning of such concepts as the power function of a test and the randomization set. In this way we believe that the statistical method of approach can be more readily grasped by the average student.

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Finally, a few comments on alternative routes by which to reach our objective. We have had experience of two main routes:

(1) It is possible for students taking the B.Sc. Special Degree in *Mathematics* at University College to sit for six of their eight Finals' papers after two years and then to transfer entirely to the Department of Statistics for a year of theoretical and practical work, ending in the two remaining degree papers, in their case, purely on mathematical statistics.

(2) It is also possible to take a B.Sc. Special Degree in *Statistics* in 3 years. Here in addition to a first year ancillary science subject, carrying the school training a little further, the student takes about 80 hours of mathematics in each of his first two years as well as his main course of statistics.

What conclusions do we draw from comparison of the alternatives? Very briefly, I think our impression is that while the most able students following the first plan can become very good mathematical statisticians if they remain for a postgraduate year or two, the average student has absorbed rather too much of the mathematical discipline to find it easy to learn to think statistically in one year. This is the difficulty that later speakers will refer to. On the other hand, while the second plan, with its second year mathematics syllabus aimed at developing just those mathematical tools which the mathematical statistician will need, has many advantages, the timing is not quite satisfactory. The student needs some of the mathematics for his statistics before it has been taught him. To improve this timing it is becoming clear that we want rather more mathematics and less statistics in the first year, with a reversed balance in the second year.

But whatever we arrange at university level one thing is clear. It would be much easier to teach mathematical statistics at the university if all boys and girls taking scientific subjects at school had been made aware, through their physics, chemistry or biology, of the need for a statistical approach to scientific experiment.

Dr. J. WISHART:

Teaching of Mathematical Statistics at the University of Cambridge.—If Mathematical Statistics be defined as the study of statistics treated as a mathematical discipline, then the subject was first introduced in Cambridge in 1931 as one of the twin duties of the newly-appointed Reader in Statistics. (The other duty was that of carrying on the agricultural statistics taught by Mr. Udny Yule since 1912, while separate provision was made in the Economics Faculty for carrying on his economic statistics work). Development within the Faculty of Mathematics was at first slow, but following the second world war considerable expansion took place, and the present position will be best understood by detailing the successive stages in a mathematical education in which statistics figures as a subject. At the lowest end, only just qualifying to be called mathematical statistics, is the course forming some 20–25 per cent. of the work done in "half-subject" mathematics for the Natural Sciences Tripos. A parallel, but more rigorous, course is given in the first year of the "whole-subject" mathematics for the same Tripos. A course called "Random Variables" figures in Part II of the Mathematical Tripos. Two courses on mathematical statistics covering the basic theory, plus two probability courses (one offered by Professor Jeffreys though not this year) form a group for Part III of the Mathematical Tripos (another group consists of courses on genetics). Beyond this, there are courses for graduates which may change slightly in character from year to year, but in any one year the students can have a good selection from subjects like stochastic processes, design of experiments, combinatorial statistics, multivariate analysis and sampling theory. For the benefit of graduate students in particular (and of the staff) a small Statistical Laboratory was founded in 1947 and took over its present (temporary) premises early in 1949. The students working there are nearly all students for the University's Diploma in Mathematical Statistics, awarded for the first time in 1948. This marks one year's work at a fairly high theoretical level for students with adequate mathematical and statistical background (those not so well qualified may be admitted to spend two years over the course), but the students must in addition do work throughout the year in some applied field, of which examples are economics, agriculture, medicine, psychology and genetics. A few graduates are research students of the University, working towards the Ph.D. degree, but their number is very small at present.

All the foregoing work is organized within the Faculty of Mathematics (with the help, in the case of the Natural Sciences Tripos courses, of an inter-Faculty advisory committee). The Faculty

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of Economics offers a course for Part II of the Economics Tripos on the theory of statistics at an intermediate level. Other courses in the University, which might just merit the description mathematical statistics, are (1) an optional course in statistics for the Chemical Engineering Tripos; (2) an optional course in statistics for the Archaeological and Anthropological Tripos; these are based on a general course given every year in statistical methods (this is part of that other duty originally undertaken by the Reader in Statistics, but the Faculty of Mathematics is now responsible, through the Statistical Laboratory, for this general course) but supplemented by extra lectures of a mathematical character.

Courses in practical computation are held in connection wth the general course just mentioned, and also along with the Part III basic courses. Seminars are held in the Laboratory throughout the session, and attract the graduate students and visitors from the Mathematical and other Faculties.

Our experience at Cambridge is that students are generally able to follow the course work on mathematical statistics provided they have reached an adequate standard in mathematics. This proviso is very important, and causes the principal difficulty in deciding whether to admit applicants to the Diploma course, especially from overseas. Even if students are permitted to take two years over the Diploma, they still need a fairly high mathematical standard on entry. In recent years the number of applicants has been large, and it has been necessary to limit the number accepted to twelve or so. The Statistical Laboratory, as part of its job, would like to see introduced a Diploma in Applied Statistics for those who have not graduated in mathematics but would like to obtain a qualification in Statistics, but so far the University has not approved such a development. This raises the question of whether it is better for statistics to be under the direct control of the Faculty of Mathematics or independent. At Cambridge it was undoubtedly an advantage at first to work within the Faculty of Mathematics. Many able students of mathematics were attracted to the study of statistics, and made their mark there. The disadvantage is that the whole-time study of statistics necessitates continuous application to other sciences, and an "open door" for consultative advice to men from other laboratories, and these are features that it is difficult for the mathematical authorities to appreciate, especially in relation to lecturing hours compared with those lecturers who have no such "outside" duties. At present the disadvantages strongly outweigh the advantages, for we lack the co-operation we have a right to expect from the Faculty of Mathematics, which nevertheless exerts an inhibitory influence on our desire to expand in service to the University generally. Today statistics is not represented on the Appointments Committee nor on the Degree Committee of the Faculty, nor does it have a voice on the Committee just set up to review the needs of the Faculty for the quinquennium 1957–62. I need hardly stress the disastrous consequences for statistics which might easily ensue were such a state of affairs allowed to continue for long.

The lack of good Ph.D. candidates is at present causing some concern, *vis-à-vis* other branches of mathematics. But there is no doubt that the Diploma course gives a better all-round training in statistics for those who want to become statisticians. By the time the Diploma is earned, economic considerations generally mean that the student has to "go down". It is a matter for consideration whether it would not be a good plan to allow selected able students to count the Diploma year towards the three years' work required for the Ph.D. This is, of course, a matter of a particular University's regulations, but if something of the sort were possible, then it might have an advantage in the reverse direction. Every research student could work towards the Diploma in his first year, but those who did not do too well might be persuaded to end their graduate studies at this point.

A brief schedule of courses offered by the Faculty of Mathematics is given in Appendix 2.

Professor G. A. Barnard:

Teaching of Mathematical Statistics at the University of London.—The University of London can take pride in the fact that it was the first in the world to make special provision for the study of mathematical statistics as an independent discipline. It remains today well in advance of other British Universities in the provision it makes for the subject, although, if we look at the world as a whole, some American Universities could now be said to rival, if not to surpass, it in this respect.

Anyone who has tried, as I have, to use the statistics published by the University Grants Com-

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mittee as a basis for calculations, will have realized that such figures are largely meaningless because of the lack of precise definitions; and although one would not like to miss this opportunity of suggesting that a review of methods here should be undertaken by one of Mr. Campion's staff, it would be wrong to hold out the hope that very much improvement could be effected thereby. For, fortunately, personal contact between teacher and student still plays an enormously important part in our University teaching, and this implies that there is very great variation in the courses pursued by individual students, and they are therefore ill-suited to the grouping together required for any simple statistical analysis or for any simple description of a non-statistical kind. It follows that any brief account, such as the present one, will be wide open to attack on grounds of inadequacy.

Mathematical statistics is at present studied in the Faculties of Arts, Science, Economics, Engineering, and Medicine. The Faculty of Theology has so far resisted the statistical approach, and our lawyers do not yet weigh their evidence with a calculus. Noise is statistical, but musical notes are not, and the Faculty of Music seems to make no use of statistics either. The Faculty of Arts remains largely immune, except for subjects such as mathematics, geography and psychology, which may be thought to have a claim for promotion to the Faculty of Science, if they are not already there. In the Faculty of Medicine the teaching of statistics is exclusively post-graduate, some study of the subject being required for such post-graduate diplomas as the Diploma in Public Health. Apart from some optional post-graduate courses, in the Faculty of Engineering the teaching of statistics is exclusively undergraduate, and when the subject is taught it forms part of the mathematics course required of all engineering students. It is in the Faculties of Science and Economics that mathematical statistics appears as a discipline standing on its own feet. Here it is taught at all levels, undergraduate and post-graduate. At the undergraduate level mathematical statistics appears in all concentrations, as it were, from the pure undiluted degree course in statistics given at University College, to the courses for the B.Sc.(Econ.), with specialization in statistics, and the course for the B.Sc. in mathematics at Imperial College (both of which include a considerable amount of mathematical statistics), to the statistics courses for the B.Sc. General degree, the one- and two-year ancillary courses in statistics for the B.Sc. degrees in Botany, Zoology, and similar subjects, and finally the pinches of statistics sometimes added as flavouring to mathematics courses for physicists and chemists. At the post-graduate level students from either Faculty may work for Master's or Doctor's degrees in the subject, and at Imperial College there is a post-graduate Diploma in Statistics.

It may be noticed that there is a perfect correlation between the teaching of statistics in a given Faculty, whether or not the Faculty possesses a Board. Resisting the temptation to pun, I should like to observe that this correlation is not altogether a nonsense one for any Faculty possesses a Board of Faculty if it contains more than one Board of Studies. Those Faculties, therefore, which are in a state of growth and development leading to fission of one subject from another have Boards, while those in which little development takes place will not have Boards—and they will not have statistics either.

From the point of view of staff there are three Departments of Statistics in the University—at University College, at the London School of Economics, and the Department of Medical Statistics at the London School of Hygiene and Tropical Medicine. At each of these Departments there is a Chair, while the Department at the London School of Economics has two Chairs. In addition there is the newly created Chair in Statistics in the Mathematics Department at Imperial College. Readerships in mathematical statistics exist (though they are not necessarily so titled) at University College, the London School of Economics (where there are two) and at Imperial College. In addition there are a round dozen recognized teachers in mathematical statistics, and a number of statistical consultants attached to other Departments in the University. For example, the Department of Biometry at University College, the Psychology Departments at the Institute of Psychiatry and at Bedford College, and the East Malling Research Station all have their statistical consultants. While it should not be forgotten that the Alter Mater (*sic*) of statistics, Rothamsted, is associated with the University as an "Institution having recognized teachers". Combined, these represent a formidable teaching force, as big a concentration as could be found anywhere in the world. It would seem fair to say that any student who used to the full the inter-collegiate facilities of the University could obtain as broad a statistical education there as anywhere else in the world.

We may remark here that, as in the country as a whole, if we compare the ratio of professorial

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staff to non-professorial staff in statistics with that found in other subjects, particularly with other subjects in which so much of the teaching is done at the post-graduate level, we find that the ratio in statistics is lower than in other subjects. This relative shortage of senior posts is cause for some concern, since it seems likely to lead to a revival of the exodus to the New World which was such a marked feature of the inter-war years.

Before leaving this review of the position with regard to teaching staff, and in case an unduly complacent impression may have been given, a very serious gap in the provision for teaching should be noted. There is no provision within the University of London for teaching mathematical statistics to evening students. In view of the importance of statistics in industry, and the fact that industrial chemists, physicists, and others could gain so much from an acquaintance with non-elementary statistical ideas, this means that a wide field where teaching is needed is left wholly untouched. Several of the Polytechnics provide courses in statistics, and these are well attended. But it is not at present possible for evening students to pursue internal courses of study in statistics. Birkbeck College exists mainly to provide evening students with internal University courses, and it is to be hoped that the authorities there will soon see their way to remedy this position.

To turn now to the consideration of courses in detail, there are three ways in which a student in the University can pursue an undergraduate course at the end of which he can hope to style himself a statistician, in the mathematical sense. He can work at University College for the Degree in Statistics, he can work at the London School of Economics for the B.Sc.(Econ.) with statistics as his special subject, or he can take a degree in mathematics at Imperial College and exercise the options provided there so as to take as much statistics as he can. The course at University College provides for the greatest concentration on statistics proper, although in the nature of the case some mathematics must be taught—and this is represented by two mathematics papers out of six in Part I of the degree examination. For Part II of the examination some acquaintance with some field of application of statistics, such as genetics, or industrial quality control, is required. At the London School of Economics, specialization in statistics begins only in the third year, and during the first two years of the degree course a great deal of time is spent on economic subjects. At Imperial College a good deal of mathematics (including numerical mathematics) and mathematical physics is taught along with the statistics, and in the second half of his third year a student is able, if he wishes, to engage in actual experimental work. Students of Imperial College who wish to go in for statistics are encouraged to exercise this latter option, since it is our experience that nothing engenders the proper respect for the data that every good statistician should have, better than experience of the hard work that so often goes into its production.

I leave it to those present from University College and the London School of Economics to comment on their own courses. For Imperial College, I would say that I think we still spend rather too much time in the first two years on mathematical physics, and not enough on general pure mathematics—a situation which is really a historical relic of the old days when physics was the only field in which mathematics found an application to the real world. And of course we share with other universities and other subjects the difficulties caused by the shocks our school education system has undergone recently—the lack of a sound general education among so many students. But at the risk of appearing to have a narrow pride, I venture to say that at Imperial College we teach mathematical statistics in its proper setting— as a branch of applied mathematics, closely related to experimental science and technology. There would, perhaps, be something to be said in favour of making statistics, like meteorology and similar subjects, a subject which is studied only at the post-graduate level, the preliminary first degree being a degree in mathematics. But this would probably mean leaving the time for specialization rather later than it should be. And with the large amount of dead wood, in the shape of excessive quantities of projective geometry, "puzzle" problems in mechanics, and so forth, that clutters up so many of our mathematics degree syllabuses, many of the present degrees in mathematics form an unsuitable preparation for further statistical studies. One reason (though by no means the only one) for the remarkable progress in our subject that has been made in the United States in the last twenty years is the fact that their degree courses in mathematics form in many ways a more suitable preparation for work in statistics than do ours; though their lack of experimental work has had its characteristic effect on their research.

In considering courses of study for a degree with statistics, a possibility which will exist in the future though it has not yet come into operation, is found in the new Honours Degree in General

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Science. Here it will be possible to combine pure mathematics, statistics, and physics (or some other experimental subject), and it would appear that such an option will be very valuable for anyone intending to enter industry as an applied statistician.

With all the provision that exists for training statisticians, does there appear to be a danger of "overproduction"? I think not. I well remember the 1930's, when I was an undergraduate at Cambridge, and Dr. Wishart had recently begun his long and, for so long, lonely battle to win for statistics its proper recognition in the University. The days were dark with unemployment among graduates, and it was a remarkable thing that Dr. Wishart was then able to undertake that any mathematician of reasonable competence who chose to specialize in statistics could be guaranteed a job. The shortage of trained statisticians, though not now so great as then, still continues, and there are still far more posts vacant than there are trained men to fill them. So that I think there is no present overproduction, nor even a visible prospect of such a thing.

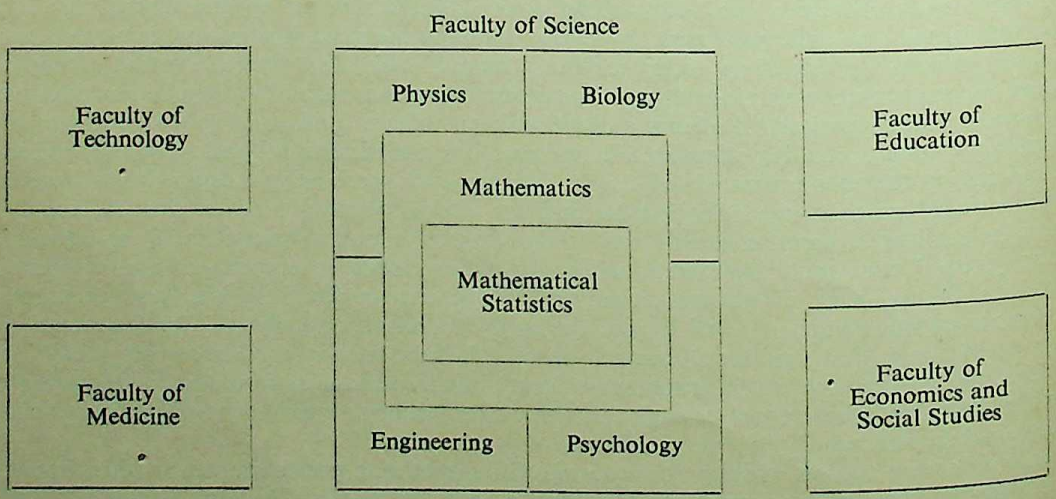
Professor M. S. BARTLETT:

Teaching of Mathematical Statistics at the University of Manchester.

1. *Present Organization*

It is well known that opinions vary on how the teaching of statistics in a university should be organized, and the Royal Statistical Society in its recommendations in 1947 made no attempt to be dogmatic about this problem. In describing the present arrangements at Manchester (with particular reference to mathematical statistics), no implication is intended that different schemes would be inferior, though as a matter of experience our arrangements do seem to be working reasonably well. It should be explained that the organization of subjects at Manchester is by Faculties, Departments and subdepartments. Mathematical statistics forms a separate section or subdepartment within Mathematics, which is itself within the Faculty of Science. Other departments in the Science Faculty which have perhaps been most interested in Statistics are Physics, Engineering, Psychology, and Biology (which is a portmanteau title for separate departments of Botany, Zoology, Bacteriology, etc., among which some departments have shown more interest than others). The Mathematical Statistics section has a rather complex but fairly logical hierarchy of responsibilities, in that it serves in the first place the needs of mathematicians, in the second, those of other science departments, and in the third, those of other Faculties. Although the other Faculties interested in statistics, namely, Economics and Social Studies, Education, Medicine and Technology, maintain their own statistical staff for teaching and research purposes (and in particular the Economics Faculty has a separate subdepartment of Economic Statistics), the responsibilities of the Mathematical Statistics section to them are by no means negligible, as liaison with such staff is maintained as far as possible, courses in mathematical statistics are open to all students able to profit by them, and statistical advice is likewise available to all departments.

In the diagram in which I have attempted to indicate this layout, I have placed Mathematical



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Statistics in rather a central position. This is no doubt a reflection of my own interests, but nevertheless I hope it is not too misleading in that the theoretical core of statistics may reasonably expect to have links with all the fields of application (and even indirectly help to keep these fields in communication with each other). I will again emphasize that no assessment of relative importance is intended; economic statistics in particular forms an indispensable part of economic studies, and the Departments of Mathematics and of Economics are both orthodox avenues for university students who wish ultimately to become professional statisticians.

2. *Present Courses in Mathematical Statistics*

Next let us consider the actual mathematical statistics courses which are given. By courses in mathematical statistics I mean statistics courses given by the mathematical statistics staff. The need to cater for students with various levels of mathematical ability means that the more elementary courses may not be more mathematical than the courses given by the statistics staff in some of these other relevant Faculties, but I can speak more competently about the courses in my own department, and I think it is fair to say that they straddle the entire range of possible levels of mathematical statistics courses.

Undergraduate Courses

(1) *Elementary course*—This is a short introductory course of about 12 lectures given in the first term and intended for students from science departments with only a very elementary knowledge of mathematics. It has been attended voluntarily by most students, although this year for the first time it was made one of the official statistics courses for undergraduates taking Psychology.

(2) *Subsidiary course*.—This is an intermediate course of about 60 hours (36 lectures, 24 hours practical class). It has two main functions:

(*a*) Students taking an Honours degree in Mathematics are required to take two "Subsidiary subjects" during their first two years, and statistics, taken in the second year, may be taken as one. (This arrangement has the advantage that the mathematicians may begin to study statistics in not too theoretical a way, the practical classes being an important part of the course, and the level of mathematics required being still elementary, e.g. simple calculus, expansions of $(1 + x)^n$, e^x and $\log (1 + x)$, etc.)

(*b*) The course is open to other departments as a fairly comprehensive course for students not primarily mathematicians, but with enough mathematics to cope not only with methods but also with the basic theoretical principles and formulae. It ranks, for example, as an official course for economics students specializing in statistics, and has this year been attended for the first time by a number of engineering students. It represents the minimum theoretical statistics requirement for students proceeding to the postgraduate Diploma.

(3) *Third year Honours course*.—This is a basic theoretical course intended primarily for third year mathematical undergraduates, who have already taken the Subsidiary course and have opted to take statistics as one of their main subjects in their final undergraduate year. It is also, however, available to other students with a sufficient mathematical background, and has been attended by Ordinary Degree students, and by Diploma and research students from other universities.

Postgraduate lecture and Diploma courses.—The postgraduate lecture courses are less permanent in character, and may vary from year to year, but are to a large extent conditioned by the requirements of Diploma students, and will thus include lecture courses on experimental design, theory of sampling, and so on.

The Diploma "course" as such is similar to Diploma courses elsewhere in being a full-time postgraduate training in statistics for students with the ability and qualifications to profit from it. It is normally a one-year course, but students often are required or elect to take two years over it; in order to have time to reach the final standards aimed at. The Manchester course has perhaps certain distinctive features. In addition to basic requirements in theory and methodology (the Subsidiary course) candidates take an optimal subject, which may be mathematical statistics, economic statistics, etc. Mathematicians normally take mathematical statistics, but must then choose a field of application (as in the Cambridge Diploma in Mathematical Statistics), and are required to undertake some study and fairly extensive practical work in their chosen field, this

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work being written up and submitted at the time of the final examination. The difference between two candidates, one of whom takes economic statistics and the other mathematical statistics, with economic statistics as a field of application, is one of emphasis. The former will have studied economics, as well as statistics, intensively, while the latter will still be primarily a mathematical statistician, who has, however, acquired experience in, and familiarity with, the application of statistics in the field of economics. To date, most candidates have been in mathematical statistics, with economic statistics as the next most probable option. It should be added that at Manchester statistics is a more intrinsic part of the undergraduate degree course in economics than it is in mathematics, so that the need for postgraduate training in statistics is perhaps less essential for the Manchester economics undergraduate specializing in statistics.

3. *Present Syllabuses*

As it is the elementary courses which present the chief difficulties both to student and teacher I will in this section reverse the order and come to the elementary courses last. The postgraduate courses are the most flexible, and I think a sufficient indication of the nature of the Diploma courses has already been given. The content of the 3rd year course for mathematicians, which is a prerequisite course for Diploma candidates in mathematical statistics, is to a large extent determined by the need to follow up, and supply mathematical proofs where previously missing, for the subject-matter of the Subsidiary course. The main new feature is an introduction to the more general approach to problems of statistical inference, especially in relation to problems of estimation.

Mathematical Statistics III (*3rd year Honours Course for Mathematicians*)

1*st term* (2 hours a week; also 2 hours a week practical class).

Recapitulation of elements of probability theory.
Laws of large numbers. Distribution and characteristic functions and their properties.
Binomial, Multinomial, Poisson, Negative binomial and Logarithmic distributions.
Central limit theorems (limit theorem for a characteristic function assumed).
Theory of Sheppard corrections.
χ^2 goodness of fit theory for frequencies. Exact treatment for 2×2 table.
Small (normal) sample theory; t test, variance ratio distribution. Applications.
General principles of analysis of variance (vector notation). Randomized blocks, Latin squares, factorial design, confounding. Linear regression and least squares theory ("independent" variables fixed).
Orthogonal polynomials and Fourier analysis.

2*nd term* (2 hours a week).

Recapitulation of theory of two or more random variables.
Correlation. Conditional distributions. Regression equations.
Normal bivariate theory.
Sampling theory of normal correlation and regression (general correlation coefficient distribution stated without proof).
Multiple and partial regression and correlation theory.
Principles of statistical inference.
Point and interval estimation. Unbiased estimates with minimum variance.
Asymptotic properties of maximum likelihood estimates for one or more parameters (proofs only outlined).
Statistical tests—power functions.
Elements of sequential analysis (if time permits).

The present syllabus for the Subsidiary course is next shown. There is the obvious difficulty with this course of catering for both mathematicians and "non-mathematicians", but in the last two years we have been able to duplicate the class and put the "non-mathematicians" all in the same class, so that a little more time can be devoted to difficulties they have with theoretical points which the mathematicians are more apt to take in their stride.

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Mathematical Statistics II (Subsidiary Course)

Part I.—Probability Theory

Introduction: definition of statistics and probability. Examples of statistical data.
Laws of probability (elementary treatment).
Statistical dependence and independence. Contingency tables.
Probability distributions. Expectation values, moments, etc.
Generating functions (probability, moment and cumulant).
Binomial and Poisson distributions.
Normal distribution.
Bivariate distributions, moments, correlation coefficients.
Introduction to multivariate distributions (very brief).
Bivariate normal distribution.

Part II.—Mathematical Statistics

Introduction

Random samples. Statistical inference, basic concepts: sampling distributions of estimators; expected values and standard errors; tests of significance and confidence intervals; examples; sample mean of normal population, standard error of sampling mean, etc.

Theory of Large Samples

Tendency to normality of estimators in large samples; sample mean, binomial and Poisson; central limit theorem (introductory). Standard errors of estimators in large samples (mean, variance, standard deviation, covariance). Tests of significance in large samples: comparison of means, variance, etc.

Sampling Techniques

Introductory treatment.

χ^2-*Distribution and Goodness of Fit Tests* (no proofs)

Properties of χ^2-distribution; distribution of sample variance from normal population. χ^2 test of goodness of fit; application to contingency tables.

Theory of Small Samples (no proofs)

Exact sampling distributions for normal population; Student's distribution (*t*-test); distribution of variance ratio (*F*- and *z*-tests); tests of significance in small samples (introductory).

Analysis of Variance and Design of Experiments (methods)

Introduction. One and two criteria of classification. Randomized blocks. Three criteria; Latin squares. Confounding. Factorial experiments (introductory).

Regression and Least-Squares

Introduction. Linear regression: bivariate, multivariate. Distribution of means and regression coefficients (no proofs); tests of significance (introductory). Polynomial regression. Orthogonal polynomials. Harmonic analysis; least-square fitting of Fourier series.

Finally, we come to the course which gives the biggest headache, the elementary course. This has been given in the Faculty of Science for many years, and in its present form is admittedly unsatisfactory. It is too short to hope to give students who have little or no mathematical background a very satisfactory introduction to the subject, with no auxiliary practical class (as in the Subsidiary and 3rd year courses). It is easy to criticize the course as including too much methodology, but it should be remembered that many students attend the course voluntarily in order to learn something about methods, and an attempt is therefore made to give them some of the most useful of these.

Having given the course myself in the last two years, I have realized some of the difficulties. I have, however, attempted to include a fairly simple approach to the sampling fluctuations (and, in particular, standard errors) of averages, leading up to analysis of variance technique as a natural

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extension of such basic results. Even at this elementary level it seems to me essential to introduce some theoretical statistical ideas, to move over from entire populations to samples, although this introduction, in fact, of the elements of statistical probability, does not of course make the teaching of the course any easier. Any suggestions for improving the course will be welcomed, but before the obvious one of making the course longer is considered further, the extent to which the miscellaneous batch of students from Botany, Pharmacy, Psychology, etc. could fit in a longer course with their other extensive lecture programmes would of course also have to be considered.

Mathematical Statistics I. (Elementary Course)

Historical development of statistics. Statistical populations and frequency distributions. Description of frequency distributions by (i) percentiles, (ii) moments (location, dispersion, skewness).

Theoretical ideas—frequency ratios and probabilities.

Binomial, Poisson and normal distributions illustrated. Relation between standard deviation and percentiles for normal distribution.

Sampling fluctuations—discrepancy between observed and theoretical frequency—χ^2 tests (no proofs given in this course)—examples.

Standard error of mean (demonstration by use of random numbers), of difference of two means.

Principles of experimental design—elimination of systematic variation—corresponding analyses of variance discussed by examples of randomized pairs, blocks, Latin squares (emphasis on arithmetic basis of analysis, but t and variance-ratio tests quoted)

Linear regression and correlation.

References

"The Teaching of Statistics in Universities and University Colleges: Report of the Council", *J. R. Statist. Soc.*, (1947), **110**, 51–7.

BARTLETT, M. S. (1949), "Mathematical Statistics and the Universities", *Univ. Quart.*, 665–71.

Professor D. G. CHAMPERNOWNE:

Teaching of Mathematical Statistics at the University of Oxford.—I should like to preface my remarks by explaining that I have interpreted my terms of reference rather more narrowly than have some other speakers: in that I have not concerned myself with the teaching of statistical theory except when it involves fairly advanced mathematics and in that I have tried to concentrate on the *difficulties* of teaching this particular branch of statistical theory rather than the achievements.

At Oxford the main emphasis in the teaching and research in Statistics is *not* on the Mathematical Statistics but on the medical, biological, agricultural and economic, etc., statistics. Statistical theory is taught to students in all these fields, but I have not regarded such theory as coming under the heading of mathematical statistics; if I were to do so, our window display would be less austere—for example, the lecture list for Statistics in the present term is fairly representative and it provides numerous courses, on various aspects of Statistics; some of these are descriptive statistics, but the majority of them could be described as Mathematical Statistics according to Professor Pearson's definition.* This I feel bound to say lest it should be thought either that we put all the emphasis on statistical mathematics and highly theoretical aspects of mathematical statistics—or, on the other hand, that our lecture programme on all kinds of statistics is still limited (as it was I believe before the war) to four or five hours a week.

Let me now skim through the points about the *difficulties* in the teaching of mathematical Statistics in the narrow sense.

At Oxford there are two classes of students who receive systematic teaching in Mathematical Statistics. Undergraduates taking the Finals School in Mathematics and graduates taking the special paper (j) in Mathematical Statistics in the Statistics Diploma.

The undergraduates are only expected to know about that part of mathematical statistics

* In order to give a more balanced account, Appendix 4(c) has been added later to show the courses offered.

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which is covered by the very elementary syllabus given in Appendix 4(a). They are usually provided by one course of 8 lectures by myself which covers this field in a sketchy and introductory fashion—followed by a more thorough course of 20 lectures given by a mathematician. This is as much as, nay, rather more than we can expect the undergraduates to attend when statistics—here called probability—receives so low a weight in terms of numbers of questions set in their examinations.

I have been unable to think of any major difficulties in the teaching of this syllabus, but there are a number of handicaps which affect teachers of mathematical statistics everywhere and Oxford provides no exception.

(1) Mathematical Statistics does not, I believe, stand in its own right as a branch of mathematics of any great importance in the eyes of most teachers of mathematics. One symptom of this at Oxford is that in Mathematics Finals only four questions on mathematical statistics are set in one compulsory paper of thirteen questions—among five compulsory and two special subject papers. The examination regulations by themselves thus afford little incentive to undergraduates to learn any mathematical statistics, and it is left to the teacher to attract them by means of the sheer fascination of the subject matter.

(2) The second difficulty arises partly out of the first. Few of the present generation of teachers of mathematics are interested in giving individual tuition in mathematical statistics, hence this subject must be largely learnt from lectures and from books. At Oxford, where the main vehicle of teaching is the weekly tutorial session and lectures are secondary, this may put at a disadvantage the undergraduate who has some inclination to choose his questions from the field of mathematical statistics.

Both these difficulties arise largely from the fact that very little mathematical statistics was taught when the present generation of mathematical teachers were undergraduates. These difficulties gradually become less as more young teachers who know some mathematical statistics are appointed. But the fact will remain that mathematical statistics is only one corner of the field of mathematics, and undergraduates can only be expected to give a small part of their time to it.

(3) A more technical difficulty is that the foundations of mathematical statistics cannot be properly taught to undergraduates without taking up a disproportionately large part of the whole time. This would be very boring for the undergraduates and one is left with the alternative of building on shaky foundations. In my short course of lectures to undergraduates I must admit that I have adopted this alternative, but some of my colleagues have been able to give more attention to the foundations of the subject.

(4) There is no time to teach mathematical undergraduates any statistics other than the mathematical theory. For all purposes except the development of mathematics, there is no branch of statistics less important* than the mathematical theory. For that theory is solely concerned with working out the properties of the theoretical models—whereas what matters—and what in one sense is most difficult—is deciding what theoretical model best corresponds to the real world situation to which statistical methods must be applied. There is a great danger that mathematical pupils will imagine that a knowledge of mathematical statistics alone makes a statistician.

This is a danger we have been particularly anxious to avoid in framing the syllabus for the other class of pupil—the postgraduate student for the Diploma in Statistics. A case could be made out that we have been only too successful in ensuring that all candidates relying on a mere knowledge of mathematical statistics without proper understanding of some field of application—economics or biology for example—should fail in the examination. We are hoping shortly to adopt the Cambridge plan by which every candidate may carry out practical statistical work in his field of application.

Four general papers must be taken: paper (a) Elements of Statistical Practice; paper (b) Principles of Statistics I; paper (c) Principles of Statistics II; paper (k) Practical Paper, (computing).

In addition to the four general papers candidates must choose two of the following special papers:

(e) Statistical methods in social studies.
(f) Statistical theory in relation to social studies.
(g) Statistical method in experimentation and sampling.

* I am setting up this Aunt Sally in the hope that it will provoke knock-down arguments to the contrary in the discussion.

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(h) Statistical practice in biometry.
(i) Statistical analysis in psychology.
(j) Mathematical theory of statistics.

So as to avoid qualifying a mere theoretician with a diploma in statistics, the combination (f) and (j) is not allowed. The syllabus for the various papers covering Theoretical Statistics is given in Appendix 4(a).

In this discussion we are mainly concerned with paper (j). This is an optional paper and since it is made pretty difficult there have usually been only about 3 candidates taking it in any year. Each candidate goes for at least an hour a week to a tutor and it is left to the tutor to see that a candidate offering paper (j) learns an adequate amount of the subject-matter.

Such candidates should be sufficiently mature to learn much of the subject matter from standard text-books like Cramér and "Kendall's Advanced Theory". But they have, in fact, been provided —rather generously considering their fewness—with lectures. A course of 32–48 lectures called Applied Statistics has covered most of the subjects appearing in the syllabus for paper (j). A more advanced course of 48 lectures called Mathematical Statistics was also provided to give a thorough mathematical groundwork. The purpose of this course was to help those students who wished to go beyond the syllabus really deep into the subject. Many of the articles appearing in the learned journals and some books such as Doob's *Stochastic Processes*, cannot really be tackled with the mathematical apparatus acquired by a representative undergraduate who has taken Mathematics Finals: the lectures on mathematical statistics aim at providing the further mathematical basis required. These lectures have been attended not only by candidates for the Diploma taking paper (j) but by various other research students and senior members of the University. A list of subject headings for this course is given in Appendix 4(b).

I myself have been mainly concerned with teaching for the general papers and the special papers related to economics; but I have been sufficiently well in touch with the teaching of mathematical statistics to suspect that the following difficulties exist.

Candidates for paper (j) are usually persons who have obtained a second class, not a first class in mathematics finals. One explanation of this may be that, as noted earlier, Mathematical Statistics may not at present be regarded among most teachers of mathematics as a very serious or interesting branch of mathematics. Such candidates are only too ready to accept uncritically the statistical orthodoxies of the decade, without recognizing that the subject is in an early stage of development. In our anxiety to get these candidates to pass the examination we are in danger of turning out experts in a particular corpus of statistical theory and method, who may be unable to adapt themselves to new theories and methods as these are developed, and in twenty years' time may hold important posts, but become obstructive to modern ideas, because of the inelasticity of their outlook.

Another difficulty is that even where the mathematical candidate is able to gain practical experience in the application of statistical methods he may find that there is a decided hiatus between the kind of methods he in fact uses, and the more interesting branches of the mathematical theory. It is difficult to bring home the relevance of a thorough mathematical grounding to any practical issues.

This is sometimes due to the fact that the use of advanced mathematics is needed to give generality to a theorem that appears to be obvious in some narrower class of cases which nevertheless include nearly all those that arise in applications. The student interested in the applications finds it difficult to see the point of obtaining the greater generality at the expense of a long excursus into the higher mathematics.

To recapitulate, I would say that many of the difficulties of teaching mathematical statistics arise from the fact that on the one hand it is regarded by most statisticians as only a small part of the equipment of a statistician, and on the other it is regarded by most mathematicians as a rather unimportant and uninteresting branch of mathematics. But I believe that in the course of decades both these difficulties will grow slightly less.

Dr. D. J. FINNEY:

Teaching of Mathematical Statistics at Scottish Universities.—Although at least two of the Scottish Universities have a long history of statistical teaching and practice, I think it is fair to state that up to the present time none has developed a strong school of mathematical statistics,

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nor have many of the present generation of statisticians had their professional training in Scotland. There has been pioneer work by individuals, notably of course by Professor A. C. Aitken for many years in Edinburgh, but nowhere has this yet led to the collection of a group of people whose efforts for teaching and research are on the scale of which we have heard for some of the English Universities. I shall discuss both reasons and possible remedies, after a brief survey of the present situation with particular reference to Aberdeen.

The University of St. Andrews has been the latest to appoint a Lecturer with special responsibility in statistics, who now provides an elementary and an advanced course in mathematical statistics.* The elementary course of fifteen lectures and three tutorials, intended primarily for science students with sufficient mathematical knowledge to understand the theory, deals with basic ideas on probability and the standard distributions. The advanced course, for honours mathematicians who opt to take statistics as one of two optional papers in their final examination (there are usually only two or three students), consists of forty lectures and nine tutorials; the syllabus includes the same topics treated in more detail, together with additional material on the analysis of variance, the theory of least squares, and estimation theory. In Glasgow also there are two courses. The first is intended as an alternative to higher mathematics for one of the subjects taken by students at the higher standard in the ordinary degree examination. Only about six students out of eighty take this course, which is concerned with probability, frequency distributions, and the elements of sampling and tests of significance. Students taking this course have had previous courses in mathematics, which are supplemented by lectures on pure mathematics needed in statistics; the statistical teaching itself occupies nearly 100 hours of lectures and tutorials with 50 hours of practical work. The more advanced course, intended for candidates seeking honours in mathematics and political economy, includes twenty-five lectures in the third year and thirty in the fourth year; the same subjects are taken at a more advanced level, together with work on general estimation theory. This course is compulsory for mathematicians who are also reading political economy, and otherwise optional. At present there are about twenty students in the third year and none in the fourth year. In Edinburgh the one course on advanced statistics consists of forty-eight lectures, with a syllabus rather similar to that for the advanced course at St. Andrews. It is entirely voluntary and is usually attended by two or three honours mathematics students who will be examined in it, together with a larger number of graduates and undergraduates from other fields of study.

At Aberdeen in recent years, two types of course have been provided for honours students of mathematics. In their second year, all prospective honours students have about nine lectures in mathematical statistics, designed to give them a broad view of the subject and to enable them to discover whether they later wish to specialize in statistics. In so short a time, no systematic development is possible, and in my own first attempt at the course this term I am trying to outline a variety of topics. Thus three or four lectures will relate to probability and elementary methodology, perhaps three more to illustrations of the use of statistical ideas in scientific research (including analysis of variance and experimental design), and the remainder to a brief survey of one or two more advanced lines of work (e.g. estimation theory, sequential sampling, biological assay, or stochastic processes) that seem likely to interest the group. P. G. Hoel's *Introduction to Mathematical Statistics* comes nearest to my own ideas for the content of this course, but I think it will take several years to develop a syllabus really well suited to show the essential character of mathematical statistics within the time available. At a more advanced level, in the past a course of about forty lectures and forty hours of practical work has been provided as an option for third or fourth year students. The number of students is small, because of the severe selection applied to those wishing to continue with the third year of the mathematical honours course; consequently statistics can be put into either of the two senior years and lectures need not be given annually. There are no lectures at this level in the present year, but in 1955–56 a course will be arranged for all in either the third or the fourth year who want it; the syllabus will then be revised.

The Scottish undergraduate, who has left school after less intensive specialization than is customary in an English sixth form, continues a broad programme of study for his first one or two years. I can speak only from personal knowledge of Aberdeen, though I believe the general pattern to be similar elsewhere. There the man who seeks honours in mathematics will devote

* I shall not discuss the courses in each University that are arranged for economists and students of various sciences.

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his final two years to mathematics alone, but for two years must also take courses in other subjects and attain a satisfactory standard in them. (The choice is wide, and the degree ultimately obtained may be either M.A. or B.Sc.) In his final examination, he has five compulsory papers and a sixth on a special subject of his own choice. Mathematical statistics is one of the options for this last, the course of instruction being that already mentioned, and about one-sixth of the student's time for his last two years should be available for it. There is also the possibility of taking honours in mathematics and natural philosophy jointly; this opportunity is used by few, but—unfortunately, from our point of view—these are often especially able mathematicians who are thereby kept from serious specialization in statistics.

I have yet to see at first hand how this scheme works out. In the past, more than half of those permitted did in fact opt for the special paper in statistics, and several have taken up statistics as a career. We intend that the course shall give a mathematician a sound basis of statistical theory; I think it is apparent that, in the time available, we cannot provide sufficient breadth and depth of training to make him already a statistician. In some English universities that teach statistics extensively, either to undergraduates or to graduates, not only are more advanced courses on single topics (probability, estimation, stochastic processes, experimental design) available for giving much more detailed teaching than any existing course in Aberdeen or elsewhere in Scotland can do; in addition, a student can begin to develop his special aptitude for some field of applied statistics (sampling, quality control, biometry, econometry) through lectures and practical experience. The employer of statisticians is coming more and more to look upon such specialized training as the function of the university, instead of its being a product of experience during the first few years of employment.

In Aberdeen, statistics has been taught for very many years (although syllabuses have changed greatly) and my department remembers with particular pride the work of J. F. Tocher for biometry. Now strengthened by increased University staff and by establishment of the Agricultural Research Council's Unit of Statistics, we hope to make an increased contribution to statistical theory and practice. Obviously we must investigate the possibility of doing more for the training of mathematicians in statistics, not only because that is a fundamental responsibility for the Department, but also because only so can we hope satisfactorily to meet our own needs of staff recruitment. That a young mathematician should change his university for any postgraduate training he requires is often excellent, but we need to be able to compensate for our losses by attracting good men to Aberdeen from elsewhere. In a university, high quality of staff, good students for training and a good programme of instruction must be closely associated.

There are three lines of approach to this problem. First, statistics might be recognized as a full subject for an honours degree, necessarily taken in combination with certain courses in pure mathematics. The danger here lies in demanding too full a study of statistics from the immature mathematician, and never giving him the breadth of mathematical knowledge that he may eventually need. Though statistics is a discipline in its own right, not merely a branch of mathematics, I am convinced that a firm grounding in mathematical outlook and technique is the surest foundation for a professional statistician; any proposal to award a first degree in statistics must guard against weakening this foundation by too early concentration on the utilitarian aspects of mathematics. Even a scheme for allowing honours in mathematics and statistics jointly, on the analogy of the existing mathematics and natural philosophy option, might prove unsatisfactory on this account, though it is a possibility we must consider.

Secondly, we might establish a diploma or higher degree in statistics requiring one or two years of graduate study and awarded on examination. This has been tried with success at Cambridge and Oxford for several years, and appears to me to offer better opportunities for a mathematician to gain sufficient mastery of the other discipline either to pursue research in statistical theory or to become an applied statistician. Much as I would like to adopt a scheme embodying the best features of existing diplomas, however, I foresee administrative difficulties because of lack of precedents in Aberdeen.

Thirdly, a graduate in mathematics can take up a statistical problem for a Ph.D., and gain experience of the broader aspects of statistics during his two or three years of research for that degree. This is undoubtedly right for some, but a man whose initial knowledge of statistics is small is apt to concentrate on the intricacies of one difficult piece of theory to the detriment of his general education in statistics, and to become a mathematician whose special field is statistical mathematics rather than a statistician. Of course I am not condemning this result, but merely

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pointing out the consequences. Certainly we need to cater for Ph.D. students, and a fortunate conjunction of research topic and man will sometimes result in the production of an outstanding statistician. None the less, the ease with which a Ph.D. in statistics can be fitted into existing regulations must not blind us to the importance of evolving a scheme of training in statistical technique that will meet present and future demands for applied statisticians in many fields.

I am myself so newly arrived in Aberdeen that it is presumptuous of me to speak for the Scottish Universities. Nevertheless, the extension of teaching in all fields of statistics will soon be an urgent problem for me. I have therefore welcomed this meeting as an opportunity of formulating my own views, and even more as a gathering of experience and opinions from all parts of Britain for the guidance of those of us who yet have far to go. My chief regret is that we must exclude from our discussion the instruction in statistics given to non-mathematicians. The growth of our subject in recent years is chiefly due to the stimulus of problems arising in science and in economics. Statistical theory can be, and sometimes is, studied in the abstract just as is, say, the theory of infinite series, but I believe that a healthy statistical department will avoid the sterility of excessive emphasis on this approach and will seek the closest co-operation with other departments, both in providing instruction for their students and in assisting their research. The teaching of mathematical statistics needs to be seen against this background: at an elementary level, it must keep *all* young mathematicians aware of the existence of statistical theory and the aims of applied statistics, while through more advanced training it assists the few who will become professional statisticians to achieve not only a proper technical skill but also the right outlook on the function of the statistician in society. We cannot adequately discuss the teaching of mathematical statistics unless we have this larger purpose in mind, and it is unfortunate that time prevents us this evening from a broader sharing of information.

I must not end without expressing my thanks to Mr. J. R. Gray, Dr. D. N. Lawley and Professor R. A. Rankin for information on the other Scottish universities, and to colleagues in Aberdeen who have corrected some of my errors.

APPENDIX 1

Courses in Statistics Given at University College London

Courses are provided for the B.Sc. (Special) Degree in Statistics, for the third year of the B.Sc. (Special) Degree in Mathematics, and for Statistics as a one-year or a two-year ancillary to other subjects in the Faculty of Science. In addition, certain short lecture courses are provided for special categories of students wishing to obtain a knowledge of statistical methods.

As far as practicable, after each lecture on statistical theory students are given material on which to illustrate the techniques and associated ideas developed in the lecture. Each student has a desk and a hand calculating machine, and there is a demonstrator in attendance to help with difficulties.

(1) B.Sc. (Special) Degree in Statistics

Minimum entry requirements: passes at Advanced Level in the General Certificate of Education (or an equivalent qualification) in three science subjects which must include Pure Mathematics; in practice a high level of achievement in mathematics is insisted on.

The course in Statistics is spread over three years and is associated with the following ancillary subjects:

(i) A one-year course in one of the following subjects: Biology, Chemistry, Psychology, Physics, Zoology.

(ii) A two-year course in Mathematics.

Statistics Special Courses

First Year

S 1.1 *The elements of statistical theory.* Measurement of variation and correlation; sample and population; the normal curve. Applications of binomial, Poisson and hypergeometric series. The χ^2 tests. The normal frequency surface and associated correlation problems. The elements of sampling theory and the analysis of variance. (About 40 lectures.)

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S 1.2 *Interpolation, quadrature and elements of finite difference theory.*
(About 15 lectures.)

S 1.3 *Elementary probability.* Fundamental theorems in probability with illustrations. Random variates. Theorems on expectation. Tchebycheff's theorem. Binomial and multinomial formulae; Poisson's limit. Estimation of parameters of a linear function. Derivation of standard errors. Elements of quality control and sequential analysis.
(About 30 lectures).

S 1.4 *Practical Laboratory Course.* Students are instructed in the use of tables and calculating machines, and are given illustrative problems to work out bearing on the subject-matter of the S 1.1, S 1.2 and S 1.3 lectures.

Second Year

S 2.1 *Analysis of variation.* Transformation of probability laws. Derivation of fundamental distributions. Analysis of variance appropriate to single, double and multiple classifications; analysis of regressions. Randomization; randomized block and Latin square layouts. (About 40 lectures.)

S 2.2 *Second course on probability.* Probability laws. Characteristic functions; the Laplace-Liapounoff theorem. Inequalities for moments. Composition of distribution functions. Generalized theorems on least squares. Application of Markoff method for test of a linear hypothesis. Sampling stratified populations. Probability theory in testing statistical hypotheses and in estimation. Stochastic processes.
(About 30 lectures.)

S 2.3 *Systems of frequency curves.* (12 lectures.)

S 2.4 *Problem class.* (25 lectures.)

Third Year

(a) The following courses are given regularly as part of the degree syllabus, the last two with co-operation of other Departments.

Advanced analysis of variation, including multivariate analysis and special problems in the design of experiments. (15–20 lectures.)

Statistical Genetics. (10 lectures.)

Economic statistics; sources and methods. (15 lectures.)

(b) The student must also select for Part II of the Degree, two special subjects from a variety of alternatives. The advanced lectures given in the Department in this category have varied from year to year and have included groups of 10 lectures on each of such subjects as:

Combinatory Analysis. Auto-regression and serial correlation. Advanced sequential analysis. Interpretation of statistical tests illustrated on special problems.

Students may also attend appropriate lectures in this category at the London School of Economics.

(c) To complete his work for Part II of the Degree, a student in his third year must select a topic for study which is not covered by lectures, and write an essay on this topic using as illustrative material such fresh data as he can find. This scheme with associated tutorials and guided reading is designed as a preliminary training for later independent research.

Examination

Part I of the Degree, taken after two years, consists of four 3-hour theory papers and two 7-hour practicals.

Part II, taken after three years, consists of three 3-hour theory papers and two 7-hour practicals.

Ancillary Mathematics

The first year of the ancillary course in mathematics is the same as that taken by physicists and chemists, excluding the lectures on Applied Mathematics. In the second year a course is arranged specially for statistics students, in which the following topics are covered:

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Algebra.—Elementary properties of determinants of any finite order. Multiplication of determinants. Matrices and elementary matrix algebra. Rank of a matrix. Latent roots of a matrix. Reduction to canonical form in the non-degenerate case. Solution of linear equations.

Calculus.—Functions of several variables. Taylor's series for such functions. Superposition of small errors. Stationary values of such functions and discrimination between maxima and minima. Lagrange's method of undetermined multipliers. Jacobians and their application to partial derivatives. Multiple integrals. Change of variables in a multiple integral. Dirichlet's Integral and extensions. Use of orthogonal curvilinear co-ordinates. Line and surface integrals. Green's theorem for two and three dimensions.

Differential Equations.—Ordinary equations of the first order. One-parameter families of curves. Ordinary linear second order equations and method of solution in series. Hypergeometric equation. Simple linear partial differential equations of the first and second orders.

Special functions, Finite Differences, Complex variables including conformal transformation and complex integration.

(2) Statistics for the B.Sc. (Special) Degree in Mathematics

All B.Sc. (Special) Mathematics students in the University attend a course of about 12–15 introductory lectures on statistics in their second year. At University College it is possible for students who have taken six papers of their final examination in mathematics after two years to study statistics wholly for their third year as part of their degree course in mathematics. Not enough students have so far selected this option to justify providing them with the third year course that would be desirable—a special integrated course of theory and practice. Accordingly in the past they have attended selected courses from the first and second years of the Statistics Special programme given above.

Alternatively a student may take Statistical Mathematics among two or more special subjects selected for the third year. This course consists of about 60 hours of lectures and problem classes.

(3) Statistics Ancillary to Other Science Subjects

One- and two-year ancillary courses in Statistics may be chosen by students whose main subjects are Anthropology, Botany, Physiology, Psychology or Zoology. The one-year course is developed on the assumption that the student has only taken school mathematics up to Ordinary Level in the General Certificate of Education, while the two-year course assumes a reasonable standard has been reached at Advanced Level.

(4) Lectures to Biologists

A ten-lecture course on elementary statistical ideas and techniques is given every year to undergraduate biologists and to such other students as desire to attend. A more advanced course of 20 to 30 lectures giving derivations of techniques and expositions of more advanced techniques (such as for example probit analysis) is given at the end of the day for such research workers in the College or Medical School as require it.

(5) Postgraduate Training

Postgraduate students wishing to acquire a qualification in statistics fall broadly into three categories:

(i) Students possessing a B.Sc. Special degree in Statistics.
(ii) Students possessing a B.Sc. degree in Mathematics with some statistical training.
(iii) Students possessing a B.Sc. degree in Mathematics.

Those persons who fall under (i) and (ii) commonly proceed to research for the M.Sc. or Ph.D. degree without further training in methods, although it is customary for them to attend the specialized courses given for Part II of the B.Sc. Special Degree in Statistics. Students in (iii) before proceeding to research follow a selected course of lectures and practical for one year (in the same way as the third-year student of the B.Sc. Special in Mathematics).

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Table Showing Hours of Lectures and Practical Class Work

Some idea of the (approximate) hours spent by the various classes of students will be given by the table below:

Class of Student	*Statistics*		*Subjects Ancillary to Statistics*	
	Lectures	*Practical*	*2-year Maths.*	*1-year Science Subject*
(1) *B.Sc. Special Statistics:*				
1st year	85	300	80	50
2nd year	105	250	75	—
3rd year	80	40*	—	—
(2) *B.Sc. Special Mathematics:*				
2nd year	15	—		
3rd year	140	200		
(3) *Ancillary Statistics:*				
One-year	50	75		
Two-year	50	75		

* Exclusive of time spent on Essay.
(*Note.*—These figures are based on a 25-week lecturing session.

APPENDIX 2

Brief Schedules of Courses Offered by the Faculty of Mathematics in the University of Cambridge

Numbers of lectures are given in brackets.

1. *Natural Sciences Tripos* (*half- and whole-subject mathematics*)

Statistics (*12 or 15*). Frequency curves; normal, binomial and Poisson distributions; significance and goodness of fit tests; elementary analysis of variance; introduction to regression and correlation.

2. *Mathematical Tripos and Diploma in Mathematical Statistics*

Random Variables (*24*). Probability theory at about the level of Feller's text-book; brief introduction to problems of inference.

Statistics I and II (*48*). Multivariate distributions; grouping corrections; cumulant estimates; significance tests, interval estimation; sampling distributions based on normal law and their uses; analysis of variance; regression; least squares; bivariate distributions, correlation; general theory of estimation; maximum likelihood; likelihood tests; general theory of inference.

Foundations of Probability Theory (*24*). Probability as the theory of additive set functions; central limit theorem; laws of large numbers; infinitely divisible laws; application to inference problems.

Stochastic Processes (*24*). Stationary processes; autoregressive processes; sampling theory; evolutionary processes; Markoff chains; applications.

Design of Experiments (*24*). General principles; randomization; factorial designs; Latin squares; incomplete block designs; series of experiments; rotation experiments.

Combinatorial Statistics (*24*). Matching problems; combinatorial procedures; k-statistics; theory of ranking and other distribution-free tests.

Multivariate Analysis (*16*). Discriminant analysis; multivariate analysis of variance, canonical correlation analysis, factor analysis.

Sampling Theory (*16*). Sequential tests for simple and composite hypotheses; sequential estimation; design of sample surveys.

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3. *General (also used for certain examinations)*

Statistical Methods (16 + optional 8). As for Natural Sciences Tripos course, plus introduction to sampling theory and design of experiments.

(This course is continued to a more advanced stage in the Faculty of Agriculture.)

APPENDIX 3

Courses in Mathematical Statistics and Related Topics given at the Imperial College of Science and Technology, London

Statistics

Histograms, cumulative curves; probability paper; mean, median, mode, standard deviation. Variance, covariance, and correlation coefficient. Laws of probability. Binomial, normal and Poisson distributions. Least Squares. Elementary tests of significance.

Numerical Methods

Principles and practice of computation and tabulation of functions. Use of computing machines. Elements of finite differences. Interpolation formulae of Lagrange, Gregory-Newton, Bessel, Gauss and Everett. Numerical estimation of differential coefficients by difference methods. Simpson, Milne, Euler-Maclaurin, Gauss and other methods of approximate integration.

Sketching contours; nomograms; curve tracing; Newton's diagram. Numerical solution of algebraic and transcendental equations by successive approximation. Sturm's functions. Solution of difference equations, with applications.

Foundations of Statistical Theory

Multivariate generalization of properties of mean, variance and covariance. Gauss's theorem on Least Squares. Multivariate normal distribution and derived distributions. Significance tests. Theory of estimation. Experimental arrangement and analysis.

Postgraduate Courses on:

Foundations of mathematics and of statistics; the theory of probability; the design of experiments; industrial statistics for engineers; advanced applied statistics; finite differences.

APPENDIX 4(a)

Syllabus for Statistics for Undergraduates Taking Mathematics Finals at the Univfrsity of Oxford

Part I

Elements of probability theory including fundamental rules for handling probability. Questions will not be set on the meaning of probability.

Part II

Distributions; specification of frequency distributions, e.g. by cumulants; chief properties of Binomial, Poisson, Gaussian and Bivariate Normal Distributions.

Part III

Random variates and characteristic functions; use of gamma functions and characteristic functions; composition rules for addition of independent random variates. Use of uniqueness, inversion and limit theorems for characteristic functions. Proof of the central limit theorem in the simplest cases.

Part IV

Applications: derivations of χ^2, t and F distributions. Simplest applications to samples from populations of normal form.

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Syllabus for Papers (b), (c), (g), (h) and (j) in the Diploma in Statistics

(*b*) *Principles of Statistics I.* (Summary)

Frequency distributions: averages and measures of dispersion. Elementary treatment of binomial, Poisson and normal distributions. Principles of sampling and standard errors, and significance tests. Linear regression and correlation (2 variables only).

(*c*) *Principles of Statistics II*

Subjects of (b) at more advanced levels, together with: Weight of observations; elementary ideas on probability; elementary use of t and χ^2 in tests of significance and in assessing confidence limits. Use of statistical tables. One- and two-tailed problems. Elementary analysis of variance and use of F-test. Elementary use of least-squares method. Multiple and partial regression and correlation. Fitting of polynomials.

(*g*) *Statistical Method in Experimentation and Sampling*

Estimation and inference from experimental results.

Analysis of χ^2; analysis of variance and covariance; regression analysis.

Principles of experimental design; randomization, replication, orthogonality. Standard designs and analysis. Analysis of non-orthogonal data. Factorial experimentation; confounding and identification of contrasts.

Transformations for non-normal data and for linearizing of regressions.

Estimation by sampling (discrete and continuous variates). Bias, precision, consistency efficiency. Random, random stratified and systematic sampling. Multi-stage sampling. Use of supplementary variates in sampling. Simple applications of principle of maximum likelihood in sampling problems.

(*h*) *Statistical Practice in Biometry*

Subjects of (g) with more emphasis on practical application. Planning of experiments for specific purposes in various fields of biology. Biological assay; basic principles, simple design, and analysis. Elementary problems in collection and analysis of genetical data. Choice of frame, sampling unit, strata, and sample size in sampling. Planning, execution, and analysis of surveys and other sampling investigations. Cost functions and the economy of sampling. Sampling of plant, animal and human communities for research in special fields of biology.

(*j*) *Mathematical Theory of Statistics*

Various theories of probability. Relations between probabilities. Distribution functions and parameters thereof. The distributions of sampling statistics. Theorems concerning characteristic functions, including the central limit theorem. Mathematical properties and interpretation of binomial, t F and χ^2 distributions. Simple and multiple regression and correlation analysis. Mathematical theory of analysis of variance and covariance, factorial design and confounding. Theory and methods of estimation from sample evidence, including sequential analysis. Autoregressive series and Markoff processes. Analysis of time series.

APPENDIX 4(b)

Abbreviated List of Contents of the Most Advanced Course on Mathematical Statistics at the University of Oxford

Abstract set theory, measure theory and probability spaces.

Sequences of random variables (convergence theorems, laws of large numbers, central limit theorems, etc., etc.)

Sequential analysis (including classical estimation theory as a special case; significance tests, etc.)

Decision function theory.

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APPENDIX 4(c)

Outline of Lecture Courses on Statistics at the University of Oxford

(Figures in brackets denote numbers of lectures or classes)

(i) *Applied Statistics* (48) (a general survey of statistical methods at about the mathematical level of Kendall's "Advanced Theory of Statistics"): *Experimental Design* (32) (Standard designs, e.g. factorial experiments, latin squares, orthogonal squares, balanced incomplete blocks etc., at roughly the level of Cochran and Cox's book). *Sampling Theory* (16) *Biological Assay* (8).

(ii) *Probability and Statistics* (8) (*Elementary*): *Mathematical Statistics* (8) (Introductory). *Theory of Probability* (24) (covering subjects in the undergraduate syllabus in Appendix I). *Advanced Mathematical Statistics* (48) (as described in Appendix II).

(iii) Discussion Classes: *Statistics for B.Phil and Diploma* (24). Topics in Probability Theory (12). *Biometry Seminar* (8).

(iv) Five courses of elementary statistics have been provided for *biologists*, *foresters*, *botanists*, *agriculturalists* and *scientists in general.* 120 hours of lectures have been given during the last twelve months on various aspects of *econometrics and economic statistics.*

Professor M. G. Kendall: The teaching problem at University College and the London School of Economics is of a different order of magnitude from that in other universities described by my colleagues. At the London School of Economics we have two chairs, three readerships and two lectureships in statistics as well as a research division which does some teaching to keep its hand in. We are, I believe, the biggest teaching unit in Europe. We have 36 courses given to audiences ranging from 10 to 300 and we devote about 930 hours a year to lectures, classes and seminars. This includes mathematics and econometrics, but not mathematical economics, demography or supervisory work. Some of these courses are concerned with practical, not with theoretical statistics. The syllabuses for the 25 lecture courses in method and theory, occupying about 400 hours, are given on p. 214.

In passing, I should like to record objection to the expression "mathematical statistics". It is far preferable to speak of "statistical method" and "theoretical statistics". Apart from the fact that the basic ideas of theoretical statistics are not mathematical, the notion that statistics is a branch of mathematics, if it gains ground, will do incalculable harm to practising statisticians. In looking at advanced books on probability and set theory I am sometimes reminded of a remark by Pascal made in an entirely different context. "Le silence éternel de ces espaces infinies m'effrait". It frightens me too. When I was an undergraduate it was possible to read for three years at the mathematical theory of electricity without knowing how a radio set worked; to read the mathematical theory of heat without knowing how a refrigerator worked; and to read astronomy and stellar dynamics without even looking down a telescope. If we are not careful we shall have students capable of deriving the most complicated and refined results in random sampling theory without knowing how to tell whether any sample they meet is a random one or not. Previous speakers have made it clear that they are alive to the danger, but I am not entirely convinced that they are in a position to combat it. To those of my colleagues whose departments are stationed in the mathematical department I will concede this, that there is one worse thing that could happen to them, and that is to be a subdepartment of a department of economics. And there is one worse thing than that, to be a subdepartment of nothing at all. But I hope that they will not relax their endeavours to attain full departmental status in their own right.

My colleagues have dealt mainly with the question of what to teach and who should teach it. There are three other topics of at least equal importance, namely where we get the students to whom we teach it, how we should teach it, and what students are supposed to do with it when they have been taught. Each one of these would require some time to discuss in detail. All I can do in the few minutes I am allowed is to outline the problems of one of these topics; and I choose the second, namely the method of teaching statistics.

University teachers are unique among professional men in having no training whatsoever in their profession. They have to learn by experience; and some of them never do learn. One would expect that in such circumstances a good deal of thought would have been given to the technique by which statistical ideas should be introduced to students. Perhaps it has, but if so

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the results have not been made available for general use. I find that there is a natural rate of intake of statistical concepts which no student, however technically competent, can exceed. If this is generally true, it means that there is a natural *lower* bound to the length of a course in theoretical statistics, and one would like to know what the period is. I suspect that it is considerably longer than one year. I find too, that axiomatic treatments are not what the student needs in order to get a fundamental grasp of the basic ideas.

I would guarantee to teach a student coming fresh to the subject more about probability with a pair of dice and a pack of cards in a week than he would learn in a month from set and measure theory. Naturally, I should prefer that he learn both approaches; but I think the experimental one comes first. And whether it should or not, I think that the whole subject of the psychology of teaching statistics needs a thorough airing. It is a large subject and I can do no more than call attention to it.

Lectures in Statistical Method and Statistical Theory
London School of Economics 1954–55

A. *General*

(Mainly for students reading Economics and Sociology)

Statistical Method I (15 hours)

Collection, definition and tabulation of data. Approximations and error. Frequency groups, time series and graphical representation. Measures of average and dispersion. Index numbers. The elements of the analysis of time series. The simplest ideas of sampling and correlation.

Statistical Method II (20 hours, given in duplicate)

Moments and cumulants describing frequency distributions. Elementary treatment of regression and correlation. Elements of the theory of probability. Binomial, Poisson and normal distributions. Introduction to the theory of sampling.

Statistical Methods (*Sociology*) (20 hours at each of two levels)

Collection, definition and tabulation of data. Diagrammatic representation. Analysis of frequency distributions. Averages and measures of dispersion. Index numbers. Time Series. The elementary theory of regression and correlation. Background of sampling theory. Calculation of sampling errors. The design of samples.

The application of statistical methods to sociological problems.

Mathematics (50 hours)

Limits and the elementary theory of convergence of series. Differentiation and integration of functions of one variable. Expansion of functions; Taylor's and MacLaurin's theorems. Maxima and minima of functions of one variable. Tangents to curves; areas and lengths of curves. Differentiation and integration of functions of two or more variables and elementary applications. Areas and volumes of solids. Numerical methods of integration. The simplest differentiation and difference equations.

Finite differences and applications to interpolation, summation and integration. The elements of the theory of determinants and matrices. The simplest properties of complex numbers, and Argand diagram and de Moivre's theorem. Gamma and Beta functions.

Advanced Mathematics (20 hours)

Vector spaces. Matrix algebra. Quadratic forms. n-dimensional geometry of lines, planes and conics. Functions of several variables. Multiple integrals. Fourier integrals.

Introduction to Econometrics (24 hours)

The scope of econometrics. The nature of statistical data available to economists. Time series, trends and fluctuations. Production and consumption functions. Derivation of supply and demand curves by regression analysis and simultaneous probability equations. Problems of identification and aggregation. Connection between micro-economic theory and macro-economic models. The theory of games. Linear programming theory and applications.

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Methods of Social Investigation (10 hours)

The nature and evolution of social investigations. Contemporary survey work. Surveys of environment, behaviour and opinions. The planning of surveys. Statistical methods in surveys. Background of sampling theory. Sample designs and sampling techniques. Non-sampling errors and bias. The use of experimental designs. Methods of collecting data: documents, observation, mail questionnaires, interviewing. Questionnaire design. The processing of data.

Compound Interest (5 hours)

An introduction to the Annuity Certain, Valuation of Redeemable Securities, Sinking Funds; the determination of interest rates in given transactions and continuous growth. Elements of Life Assurance.

Actuarial Statistics (10 hours)

Elementary Life Contingencies; some statistical properties of the Life Table and Life Table functions; Exposed to Risk formulas; Graduation; the Construction of Decrement Tables.

B. *Mainly for Students Specializing in Statistics in their Third Year of the B.Sc.(Econ.)*

Introduction to Probability (10 hours)

Development from an axiomatic basis. Conditional probability. Bernoulli trials. Generating functions. Laws of large numbers. Central Limit Theorems.

Introduction to Mathematical Statistics (20 hours)

A general treatment of frequency distributions and their properties. Binomial, Normal, Poisson and other particular distributions. Interpolation and graduation. Curve fitting.

Numerical Methods and Interpolation (10 hours)

Description of various types of calculating machines and punched card equipment. The application of these machines to computing problems arising in statistics. Topics will include the computation of moments, the solution of simultaneous linear equations, numerical integration and interpolation.

Statistical Relationship (10 hours)

Association, Contingency and Correlation. Regression and correlation analysis for two and for several variables.

Analysis of Variance and Covariance (10 hours)

One-, two- and three-way classifications. Arithmetical procedures. Theoretical background and assumptions involved. The use of transformations. Analysis of variance and regression. Analysis of covariance. Components of variance. Elementary notions of experimental design.

Introduction to Quality Control (8 hours)

Testing of industrial products and processes. Inspection by 100% screening and sampling, of raw materials, end products and during manufacture. Continuous processes. Allowable variation. Need of warning that a process is getting out of control before rejection of the product becomes necessary. Control charts and specification limits; single, double and sequential sampling. Necessity of maintaining a reasonable balance between quality and cost and between the various qualities that are desired. Tests which only indicate some of the qualities desired.

Analysis of Time Series (10 hours)

The study of seasonal movements, oscillatory movements and trends in time series. Moving averages. Curve fitting. Autoregressive systems. Correlogram and Periodogram analyses. Variate-difference method. Tests for serial correlation.

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Theory of Sample Surveys (10 hours)

Unrestricted random sampling; stratification and clustering; multi-stage sampling. Optimal allocation for given cost function. Selection with arbitrary probabilities. Ratio and regression estimates.

Estimation and Tests of Hypotheses (10 hours)

Point estimation: maximum likelihood estimators. Interval estimation: confidence intervals. Tests of hypotheses: likelihood ratio tests.

C. *Postgraduate Courses*

Multivariate Analysis (20 hours)

Component Analysis; Factor Analysis; Analysis of Functional Relationship; Canonical Analysis; Confluence Analysis; Tests of Homogeneity; Discriminant Analysis.

Autocorrelation Analysis (10 hours)

Serial correlations. Correlograms. Power spectra. Sampling theory of serial correlations. Goodness of fit of correlograms.

Sequential Analysis (6 hours)

The sequential probability ratio test. Tests of simple and composite hypotheses. Inverse sampling. Double sampling. Sequential estimation.

Stochastic Processes (10 hours)

Discrete and continuous processes. Stationary and evolutionary processes. Ergodic theory. Markov processes. Applications.

Distribution-free Methods (10 hours)

Distribution-free tolerance intervals. Confidence intervals and tests for order-parameters. Goodness-of-fit tests. Tests of bivariate independence. Two- and k-sample tests. Tests of randomness. Distribution theory and limit distributions. The consistency and power of distribution-free tests.

Design of Experiments (8 hours)

Randomized blocks. Latin squares. Factorial designs. Confounding. Incomplete blocks.

Limit Theorems in Probability (10 hours)

Convergence of variables and distributions. The First and Second Limit theorems. Laws of Large Numbers. Central Limit theorems. The Law of Iterated Logarithm.

Mr. I. D. Hill: My claim to take part in this discussion is as one of those who have recently experienced the teaching of university statistics at the receiving end. A few years ago I took Professor Pearson's degree course at University College, London.

Professor Kendall has laid emphasis upon the dangers of teaching too much theory without sufficient practical ideas. I think one of the heartening features of the present teaching of statistics is the emphasis in the contributions we have heard upon the "applied" and "practical" aspects of the subject. This is not to say that the theoretical side is unimportant. Professor Champernowne's riddle about the relative importance of the mathematical theory reminded me of the question, "Which is it more important for a car to have, an engine or some petrol?" Obviously, neither mathematical theory nor practical applications can get anywhere without the support of the other.

Nevertheless, I would make bold to say that statistics is not so much a set of methods as a way of thinking. As such it is admirably suited to be a university subject, if we accept the view that the purpose of university education should be not so much to teach people a trade as to teach them how to think; not so much to teach them to know methods and formulae by heart as to know where they can be found when they are wanted. So long as the science of statistics and the aim of university education are thought of in this sort of way by the teachers, and the teachers manage

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sufficiently to inspire the students, I do not believe there is very much danger of turning out experts who "are only too ready to accept uncritically the statistical orthodoxies of the decade, without recognizing that the subject is in an early stage of development".

It might be helpful to start students off by telling them, as I am told has been done (in the Medical School at Harvard University) that half of what they will be told during the course will in ten years time be known to be incorrect. The trouble is that none of us can tell which half.

In teaching students to think rather than merely to know techniques there is one branch of the subject which I suggest would be of particular value: namely, the History of Statistics—I do not know whether it is taught anywhere. What has been done to deal with statistical questions in the past? When, how and by whom have the methods been improved? Which methods have been dropped and why? Which methods that are generally accepted nowadays have met with opposition when first introduced? Was any of the opposition well founded? I am not suggesting that such a course should be given to all those students whose primary interest is in some other subject; but for those who set out primarily to be statisticians I think such a course could be very valuable indeed. It could certainly be valuable to the teachers in seeing how the students take it and in separating those who wish to be educated from those who wish merely to pass an examination.

Finally, I would say a word in praise of the practical examination at the end of the three year course at University College. This was designed to simulate, as far as possible, "real life" conditions. We were given two days for it, and there was just one question on the examination paper. We were allowed to have not merely statistical tables but also our own lecture notes and textbooks, and even the departmental library was thrown open as part of the examination room. We were given a large quantity of "real life" data, and we had to make sense of those figures and report our conclusions. That seems to me to be an excellent way of testing whether a student has really learnt to think statistically. In some ways it seems a pity that the examination did not include designing an inquiry and collecting one's own data, but that I am afraid would take too long.

Dr. JOHNSON: I should like to make two rather disconnected points. The first concerns the initial training of students. I think it might be worth while trying to construct a course which could be given for the initial training of all types of student. Several speakers have pointed out that the basic ideas in statistics are not essentially mathematical, and I feel that the effort of constructing a course which would get over these essential ideas and which would *have* to get these ideas over to a varied audience would be well worth the trouble, and might indeed lead the lecturer or lecturers engaged in doing this to an improved appreciation of the subject.

The second point is that I should like to emphasize the necessity for the provision of data at all stages in training statisticians, from the most elementary to even the most advanced. At the most advanced stages it may be difficult to provide data—you may have to make them up, unfortunately—but I think they should be made up, if necessary, in order that one can be convinced that what one is teaching is worth teaching.

Miss E. J. WARNER: I should like to express the views of one who is still a student. Having taken a degree in mathematics, with some statistics, I am continuing my studies in statistical theory as a part-time student whilst also employed in a statistical post.

To my mind the subject has developed in such a way and to such an extent that there now appear to be two pursuits in statistics—the practical and the academic. Ideally the two should be complementary, but so often the relationship between them is all too vague. Mathematical statistics can be an end in itself to a limited few, but for a far greater number it must also be a tool—a technical aid of the practical statistician—and should surely be always taught with this in mind. There is a real danger for the academic world to become a world within itself, with attention largely directed towards the development of abstract theories and perfection in mathematical expression. Possibly our system of University education is responsible for this. Statistics, as we have heard, is often studied at postgraduate level and, as such, a high academic standard is demanded, allowing little time to deliberate over practical interpretations. I am prepared to float along in the clouds, methodically multiplying matrices, provided I don't lose every contact with the earth. It is of little use my being equipped with the best tools of the trade if I am not shown how to use them. When we were first shown that the best linear unbiased estimate of a parameter θ is given by an expression in matrices such as $\theta = (A'A)^{-1}A'y$, how many of us appreciated its real practical meaning?

The lecturer even though biased towards the theoretical side should keep the practical aspect equally in mind. How much easier it is for the student to understand the subject and to grasp its subtleties when he is aware of the practical implications, and, moreover, how much greater use will he be to his future employer. A man is useless if he is so saturated with high powered mathematics that when confronted with a column of figures arising from actual experience he hardly

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knows how to begin to handle them or, if having calculated a correlation coefficient of ·2 with 100 degrees of freedom, he decides it is of practical significance only because his tables tell him so.

Admittedly, a good theoretical background is essential in order to be able to adapt set techniques when everyday problems fail to conform to text-book patterns, as indeed so often happens. Before one can attempt to modify any of the recognized statistical designs and tests one must have a knowledge of the theory behind them. But in pursuing the theory, one must not overlook the existence of the practical side which is after all the primary purpose of these techniques.

Miss KEEN: I was not asked to contribute to the discussion because I am a mathematical statistician, and I must say at the outset that my mathematics stopped at Intermediate level. It is with extreme difficulty that I read a mathematical text at all. However, perhaps I may be called something of a consumer of mathematical statisticians.

Until recently my experience was limited to having had over a number of years some 30 or 40 students during the summer vacation from Cambridge, University College (London) and Imperial College. They have been at various stages of training: some have had degrees in mathematics, with or without statistics; others have had degrees in mathematics and postgraduate statistics; some have been undergraduates with either first or second year training in statistics; and some have been reading science but have had a course in random variables. What most determined the difference between them was their maturity in other directions. Students who had done their national service tended to be the most mature and thus more useful to us.

My recent experience has been confined more or less to students from Cambridge and there seems no doubt that the applied statistics which they do in some chosen department is enormously useful. So far as I remember none of the men and women we have had has concentrated on industrial statistics, which is my business, but they have nevertheless been immediately very useful to us.

The number of ways in which a mathematical statistician can be fully employed on work with a high mathematical content is still very limited, especially if he is the only statistician in the firm or the firm is mass-producing several lines of articles and therefore has a lot of quality control work. In that event he must be prepared for a fair amount of routine arithmetic and data sorting, for getting on with usually rather unwilling customers and presenting his conclusions in non-statistical terms. It is sometimes a temptation for the mathematically trained statistician, who as a rule knows that his arguments and symbolism are more efficient than other people's, to think that the most efficient method of progressing would be for others to learn his methods rather than for him to learn theirs. To apply statistical reasoning to the average job the mathematician has usually to revise his views on mathematical rigour in the face of economic considerations, and his views on statistical validity in the light of the data he is required to use. It is no use saying that the data are not adequate or that they are not in the right form and therefore an answer cannot be given, because somebody is going to make up his mind if the statistician does not.

My department, which is situated in research laboratories employing 400 to 500 graduates, has been serving them and our factories for some 30 years. It was only about two years ago that we decided we could use a resident mathematical statistician, and in fact only this year have we got one. Before then we managed by using a mathematical consultant when we got into difficulties. Increased propaganda in the firm may have stimulated a need for the mathematical statistician, but I think the real factor has been the intake of undergraduates who now have to do statistics in their mathematics courses or have statistics courses as an extra. Most of them do not know how to make use of the statistics they have learnt, but at least they recognize a statistical problem and do not have the statistics phobia common to those who "did not do it when I was at school". I think this is a sufficient justification for the shortest and sketchiest of courses that statistical departments can give to the other faculties in the university.

Most problems can be dealt with by working statisticians like myself, but I think that as soon as there are two or three of us in a department we find there is room for a resident mathematical statistician to whom we can put our own problems. Perhaps I am biassed, but I think that full-time mathematical statisticians are most likely to find congenial work in the electronic industry. Problems of cathode emission, magnetron output, switchboard design and all forms of radar signalling, to name a few, need a combination of fairly complex mathematics, probability theory and random error treatment, and only someone reasonably *au fait* with all these disciplines is of any real use. In this connection one successful job attracts a large number of similar jobs and, as with all analytical and computing engines, as soon as there *is* one, then jobs will be taken on which formerly were too formidable. Finally, I think the field for the purely mathematical statistician is likely to get much bigger in industry as soon as there are more people with some appreciation of what statistics can do.

Mr. WATKINS: I should like to follow on from what Miss Keen said and plead for a much closer

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relationship than exists at present between the teaching of statistics and industry. Although there are today many more applications than ever before of statistical method that we can make to industry there is a danger that these will fail because we shall have two camps—industry with very little knowledge of mathematical statistics and mathematical statisticians with very little knowledge of industry. I would ask that if possible this fact be kept in mind if there is any review of courses.

I have one or two suggestions in mind which may or may not be practicable. Would it be possible for undergraduates taking a mathematical course in statistics to spend time with firms during the summer vacation? I do not know what approach has already been made, but I think any firm of reasonable size, particularly if not large enough to have its own operational research department, could keep a mathematician fully occupied for a month or so on a number of specific applications. Also, with regard to applied fields for the Ph.D. degree, would it be possible for more industrial examples to be taken there?

One approaches the question of science graduates from two angles, first in relation to the student specializing in mathematics, and then, what is equally important, in relation to the man taking physics, chemistry, biology, engineering, etc. Can he be given a better course in statistics? That usually provided does not teach him enough either to apply statistics himself or to appreciate the possible applications by someone else.

Another point follows Professor Pearson's suggestion regarding sixth forms. It would be an excellent idea to incorporate a little statistics into their syllabus. It would make things easier at the universities, and from the students who did not go to a university would come departmental managers and their equivalent with some idea of statistical method.

Dr. G. H. Jowett: Apart from a snippet of eight lectures in the second year course of mathematics for engineers, the teaching of mathematical statistics at the University of Sheffield is confined mainly to a course in the final year for honours mathematics students, where it is regarded as one of a group of advanced subjects. The length of this course has varied widely from year to year, from about 70 hours lectures plus 50 hours practical work (including some numerical mathematics) spread over the whole year to about 30 hours lectures with no practical work spread over a single term. The character of the course has also varied widely, ranging from an exposition of the nucleus of standard techniques with their mathematical backgrounds and practical applications to a review of types of mathematical method used by statisticians in constructing and justifying their techniques. The honours school of mathematics at Sheffield is small, usually numbering four or five students in the final year. One or two of these usually stay on to do research, and sometimes statistics is the subject chosen; others occasionally take jobs involving statistics, though they need to learn much more than we teach them before they are fit to be called statisticians. For the research students the second type of course seems better as an introduction; for candidates for statistical jobs the first type is better.

There is a considerable amount of statistics taught in the University in addition to this, but the mathematical content of most courses is rather slight, and attuned to the students taking them. Some of these courses are given under the auspices of or by members of the Department of Mathematics, others by members of other departments (e.g. education, genetics, social studies, psychology, economics) to their own students. Of these, the main course for which the Department of Mathematics is responsible is a one-year subsidiary course, taken in the pre-final year by students for the general degree of B.Sc.; this contains a little mathematical statistics (such as the manipulation of probabilities and the derivation of standard errors in simple cases), and also such topics as experimental design, quality control, vital statistics, quota sampling, and probit analysis. Students with mathematical backgrounds are not considered—or intended—to have any particular advantage over other students taking this course. From time to time other courses are given, such as voluntary ones intended for research students in other subjects, and extra-mural courses which sometimes reach quite an advanced standard.

Our main claim to originality lies in the use which we make of practical experimentation in the Honours or Subsidiary practical classes. Students do blood counts, carry out miniature agricultural experiments with varieties of grass seed in trays, run quality control schemes on miniature mass production processes, study the distribution of their own reaction times with a chronotron, and as an occasional light relief correlate the attractiveness and other characteristics of cover girls by ranking methods. I am convinced that this is worth the trouble; the collection and analysis of their own data is a valuable experience even for students whose main interest is in the mathematics of the subject, since only in this way do they learn to appreciate the real need for statistical techniques, and some of the difficulties of squaring mathematical models with reality.

Mr. Halton Thomson: I speak as a civil engineer who tries to apply statistical methods to some of his problems, and I would suggest to those who teach statistics that they should introduce the

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theory of extreme values. I have looked quickly through the various curricula given us to-day and see no mention of that subject. It is very important to civil engineers who have to deal with extreme phenomena.

I have a suspicion that many statisticians regard extreme values as a nuisance, as being really sports which they need not worry about, but in civil engineering a very high flood, for instance, is an important event; in fact it is an extreme value. Therefore, any method which gives the civil engineer the means of estimating the magnitude of such events—their sampling errors, how often they are likely to occur and the intervals between them—is worth while.

The same idea applies at the other end of the scale, that is to droughts; their frequency and intensity are statistical problems to which the theory of extreme values could also be applied. I hope therefore that teachers of statistics will include that item in their lectures.

Dr. D. A. Evans: I should like to put on record what is being done by way of teaching mathematical statistics within a department of mathematics at a northern provincial university—that at King's College, Newcastle upon Tyne (University of Durham).

There are three courses. One, given to honours mathematics students in their third year, consists of lectures on statistics for two hours a week and covers general statistical methods. There is a June examination of the usual honours type. Questions on statistics form only part of any examination paper, and the course is not necessarily given every year.

A course of forty hours' duration is given for applied science students. The majority of the students who attend this course are those taking a general engineering course with a bias towards production engineering. The forty hours available are divided into twenty one-hour lectures and ten two-hour practical periods. The initial emphasis is on the frequency interpretation of probabilities, with a view to making clear the meaning of such statements as "significant at 95 per cent.". This introduction is followed by lectures on a few standard statistical techniques such as Student *t*-tests for means and for regression coefficients, and analysis of variance for randomized blocks and the comparison of several linear regressions. In the parallel practical classes the students are given experimental results to analyse with the aid of calculating machines. The mathematical content of the course is kept, by request, to a minimum. Candidates are given a single three-hour practical examination, involving the use of calculating machines, to which they may bring any notes they wish.

The most recent venture, the third course, is for general degree candidates in pure science. These candidates could previously only take the single subject pure and applied mathematics, but may now substitute mathematical statistics for applied mathematics. Three lectures are given each week plus a two-hour practical class in alternate weeks throughout the academic year. A second course of the same duration may be taken after this course by candidates for the general degree with honours.

Dr. Johnson has mentioned the possibility of a single elementary course for a number of different groups of candidates. The practical difficulty is that this involves lecturing to diverse groups of students together for perhaps half a term. A subsequent rearrangement of the time-table so that the groups can attend for lectures at different times is then required if more than elementary statistics is to be taught. I also have the feeling that such an arrangement might appear to students to be a substitution for the genuine article. Differences in background knowledge may force such an elementary course to be an unsatisfactory compromise. For example, I have found that the weakest of the three groups finds it extremely difficult to use combinatorial formulae even in quite elementary probability problems, whereas the middle course has no difficulty in doing so.

Professor Pearson mentioned the possibility of statistical teaching in schools. Durham University School Examinations Board has recently revised its syllabus so that it is now possible to take at advanced and scholarship level the single subject pure mathematics and statistics. Approximately two-thirds of the questions on the second of the two three-hour papers set for the advanced level examination are on statistics.

Mr. Liddell: May I say a few words as another "consumer of statisticians"? It seems to me that universities insist far too much on "useless" aspects of statistics. We want to get in industry many more of the technologist type. Once outside the laboratory it is surprising what simple techniques are required and how seldom it is possible to make use of complicated ones. The statistician should be taught (*a*) basic techniques and (*b*) how to make a suitable choice of them. Probably this can be achieved only by work on real problems of industry. Such a course has been proved feasible. However, one can hardly expect teaching organizations to spend their time on such courses until the examination syllabuses are changed. It would seem that their revision is a most immediate need.

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Dr. HASKEY: I should like to say a few words on the teaching of statistics in technical colleges. There we get people who have passed the general degree in pure and applied mathematics, and people with higher national certificates in engineering, with practically no knowledge of statistics, and it is necessary to give some background to these evening students for about two hours a week for a year. After that, one can take them a little way into the theory for another year. It does seem important, as Professor Barnard has emphasized, that facilities should be given.

Facilities should be afforded to evening students to take statistics as an additional subject at London in the general degree. Technical colleges are very willing to do this and it would be a great help if some of the students could be made internal at Birkbeck.

It has been said that the position regarding training in statistics will not be really right until we have statistics as a subject at the G.C.E. advanced level. I believe one can take statistics at the G.C.E. ordinary level, and it would be a good thing if it could be done at the advanced level with a practical examination. It takes a long time to take in statistical ideas and people cannot be expected to put two years' thinking into six months, which is more or less expected of them now.

Mr. J. C. EATON: I have waited in hopes that someone better qualified than myself might attempt to change the emphasis of Dr. Finney's account of statistics in Scotland.

In the Royal Technical College, Glasgow, statistics has been ancillary to engineering, chemistry, pharmacy, etc., but with the recent introduction of College Associateships with Honours in Applied Mathematics or Applied Physics we are just beginning to teach mathematical statistics; so that I have no complaint about his omitting us in his outline.

I was glad to hear his reference to Professor A. C. Aitken, but feel that he has hardly done justice to Edinburgh, remembering work done outside the Department of Mathematics in the Institute of Animal Genetics, in Pharmacy, and by Sir Godfrey Thomson. I believe, too, that there has been a certain amount of postgraduate work by people on Department of Agriculture Scholarships in Statistics.

I should have thought that the degree of M.A. with Honours in Mathematics and Natural Philosophy was the most common mathematics degree in Scotland.

I quite agree that Freshmen are immature compared with their English counterparts, but I would point out that they are a year or eighteen months younger. This may or may not be compensated for by the duration of the Honours Course—four years instead of three. This early school-leaving age makes it very difficult to teach any probability or statistics in schools, and such teaching is in fact non-existent because there are no papers in these subjects in the Higher Leaving Certificate or the Universities Preliminary Examinations. The Scottish Universities Joint Entrance Board control the syllabus for the latter and I would strongly urge Dr. Finney to try to persuade them to come into line with England. Most people need some time to become familiar with the basic ideas of probability after meeting them for the first time ; and this time should have elapsed before they start a university course in statistics. I believe that this step would have beneficial effects on the teaching of mathematical statistics at the Scottish Universities out of all proportion to the administrative difficulties involved.

The following contributions were received in writing after the meeting:—

Mr. R. L. PLACKETT: I share Dr. Finney's regret that if we give the title of this discussion a strict interpretation, we must exclude the teaching of statistics to non-mathematicians. This important task is often done as part of the duties of a mathematical specialist, and as Professor Bartlett has given us the benefit of his experience in this field, I should also like to make one comment. With classes taking the Diploma of Public Health, or consisting of medical or biological staff, I have tried both his procedure of introducing theoretical statistical ideas, and the alternative of giving a series of recipes for standard problems. It is not that I prefer the second approach—I regard it as basically unsound—but discussion with the classes involved has convinced me that this is what they want. They are simply not interested in the structural aspects of theoretical statistics, but only in reaching a given application by the quickest possible route.

Turning to the main issue, what emerges most clearly from this discussion is that the problem of how to fit the teaching of mathematical statistics into the existing design of lectures and practical classes must be solved in diverse ways to accord with the organization of different Universities. The solution for a given University is not unique, and for this reason alone, a scrutiny of the syllabuses, with particular regard to the order in which topics are presented, has caused at least one reader to reconsider his views. I should like briefly to outline the arrangements at Liverpool, where mathematics has to be taken in combination with other subjects, notably physics, except in the final year. In the first year, we offer a general introduction, with the accompanying practical work, but it is not compulsory for students intending to take Honours in mathematics, who may prefer a parallel course in oceanography. However, the next two years can be planned together.

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In their second year, potential Honours students are introduced briefly to probability defined on discrete sample spaces. The question then arises whether to give third-year students an advanced general survey, attempting to cover most of the techniques likely to be useful in practice; or to discuss the foundations in detail, indicating some important attempts to define probability and laying particular emphasis on the calculus derived from Kolmogorov's definition, and on theories of statistical inference. At one time I adopted the first approach, but now prefer the second, which seems to me more in accordance with what undergraduate teaching ought to be like, in that the aim is to describe the basic principles from which flow the applications. I suppose that Professor Champernowne's Appendix 4(b) represents this attitude carried to its logical conclusion, and I wish that I were able to attend this splendid course.

Lastly, a few remarks about Diplomas. Several speakers referred to what they describe as the training of statisticians and Dr. Finney informed us that the employer of statisticians is coming to regard specialized training as a function of the University. If this is instead of such training being the product of experience during the first few years of employment, are the Universities being unduly influenced by the great demand for statisticians and departing from their proper function? I would affirm that a University is a haven where the study of a subject can be pursued for its own sake, and that we should be careful not to convert it into a professional institution, or merely a place where experienced lecturers dispense useful knowledge. The Diplomas at Cambridge and Manchester seem to fulfil the condition I have mentioned, and can be regarded as degrees somewhere between B.A. or B.Sc. and Ph.D. in the subject of mathematical statistics and its applications. I am not so happy about the Oxford Diploma, where mathematical statistics plays a subsidiary part in the subject of statistics, because I doubt whether statistics, as a conception abstracted from all the Oxford examination papers, is a discipline best studied in a University environment. I think rather that it is an amalgam of common sense, experience in some chosen field, and mathematics, in order of decreasing importance. Equally, I would view with caution Dr. Wishart's proposal of a Cambridge Diploma in Applied Statistics, but I hope that the principal speakers will take up this point and clarify my ideas on how far a University can, or ought to, train statisticians.

Dr. E. S. Page: The extent of mathematical statistics that is taught in the University of Durham has been sketched in the discussion. However, it is worth mentioning explicitly that the General Degree with Honours in this University is just of the type which Professor Barnard expects to be valuable for those entering industry. Here, too, the student may take courses in pure mathematics, statistics, and another science subject.

Several speakers have given their views on the organization of statistics in a University, whether it should be in a separate department, in a subdepartment of the mathematics department, or whether there should be some other arrangement. No one has explicitly raised the question of the financial dependence. If statistics is set up as a subdepartment within that of mathematics and all major proposals for expenditure have first to be presented to some board in that department there is a serious danger that these proposals cannot be considered on their own merits, but only in relation to other proposals from the mathematics department. There would also be the possibility of insufficient representation on policy-making committees, such as Dr. Wishart has experienced. If statistics is to be a subdepartment in order to preserve the most useful ties with the mathematics department there should nevertheless be suitable safeguards in the organization.

Mr. G. M. Clarke: As a statistician in the sphere of horticultural and general biological research, I should like to make a few remarks on the subject of mathematical statistics as it appears in such work, and the implications in training people for such work. Undoubtedly consultants in this sphere will have taken a Diploma or long-term degree qualifications in statistics, in the former case presumably based on a mathematics degree. Until very recently, it was not always possible for the undergraduate mathematician to take any statistics. To-day it is by no means compulsory, though one assumes a potential statistician will decide early enough in his university life that he is going to specialize in that sphere. Postgraduate Diploma work for members of Oxford and Cambridge colleges (and no doubt elsewhere), if they are relying on college or other maintenance awards, is almost inevitably curtailed to one year, though some may be fortunate enough to spend two on an additional qualification of this kind. There are thus two extremes: a mathematician coming comparatively fresh to the subject with one year in which to do or die, and one who has a fair knowledge of the fundamentals of mathematical statistics, with two years ahead of him. The latter is in a formidable position to cope with all types of mathematical statistics, but is, I suspect, very rare, the usual situation being nearer to the first extreme. From experience of the Oxford course I am convinced that great importance attaches to fostering the correct attitude to the practical problems and use of appropriate standard theory in experimental work, and this inevitably takes time. There is also a considerable volume of elementary statistical practice which

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no mathematician will have learnt as an undergraduate—again time-consuming. Hence the opportunity of application to pure statistical theory is limited. In this, the deeper theory of experimental design must have its place; unless this is adequately covered, consultative work, which rarely runs smoothly along fully established tracks, is made much more difficult and hazardous. The priorities in the remaining mathematical statistics must then be given to topics which are likely to be of importance in solving the problems occurring in applied statistics; hence there must at least be adequate coverage of established repertoire. Undergraduate mathematics honours syllabuses include much that is valuable in the everyday tool-kit of a statistician, and provide also an excellent mental training of an appropriate kind, so that the person who obtains a mathematics degree before turning to statistics is very far from having wasted the time involved. But in the same way that no mathematician claims a knowledge ranging from projective geometry to thermodynamics, knowing rather his own special world with general principles of the rest, so should the university-trained statistician feel with regard to modern developments of which he has heard less fully than he might wish, treating the expert in such things as at least an equal.

A brief comment on another point: the introductory courses in statistics essential to research biologists can scarcely be glorified by the name "mathematical", largely owing to the wholly inadequate time such people were able to spend at school on sixth-form mathematics. At least two hours a week, on algebra, calculus and the like, ought to be possible even in the most "subsidiary" of sixth-form syllabuses.

As a result of the ballot taken during the meeting, the candidates named below were elected Fellows of the Society:

Richard Harold Hughes Bird.
Alan Bugden.
Maurice Davies.
Oliver Evan Griffiths.
Stefan Gielnik.
Keith Brian Haley.
George Anthony Harris.
Eric Heap.
Rex Raymond Philip Jackson,
Richard Humphrey Simon Lesser.
Herbert Arthur Ireland Madgwick.
Adnan Mahhouk.
Eric Page.
Herman Eric Peries.
Aditya Prakash.
John Douglas Randall.
Basil Wilfred Schwarz.
William Barry Wakefield.
Eleanor Joyce Warner.
George Edwards Wiggins.

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Farm Wages in Central Scotland from 1814 to 1870

By George Houston

Lecturer in Agricultural Economics, University of Glasgow

The obvious starting-point for a study of farm wages in nineteenth-century Scotland is the article by Bowley published in 1899 and covering the period from 1790 to 1892 (Bowley, 1899*a*). The information for Scotland, Bowley found, was "not so discursive nor so complete as that for England". Information for the years between 1814 and 1860 was particularly scrappy, and, in a subsequent article in which Bowley attempted a comparison of Scottish and English farm wages he used an index of Scottish wages which depended on interpolation for the years between 1814 and 1839 and the latter year and 1860 (Bowley, 1899*b*). Interpolation was made for the period from 1834 to 1845 on the hypothesis of uniform change, and for the remaining years by comparison with English figures. Neither method is satisfactory and the second hypothesis begs a question it would be interesting to answer.

The main purpose of the present article is to supplement Bowley's study by presenting *annual* data for the fifty years or so following the end of the Napoleonic wars. An attempt will also be made to compare the movements of farm wages in Scotland and the rest of Britain. The sources which will be used were untapped by Bowley, who depended mainly on the Old and New Statistical Accounts, the General Views of the Agriculture of the various counties of Scotland, and an article by F. Purdy in 1862 (Purdy, 1862).

Our chief source is newspaper reports of cash wages agreed between farmers and ploughmen at an important hiring fair in Perthshire, a large agricultural county in central Scotland.* The fair, known as "Little Dunning Market", used to be held in Perth every October and many farmers and farm workers attended it from all over the county. The local newspaper, *The Perthshire Courier*, which started publication in 1809, invariably printed a short account of this fair, but it was not until 1819 that it became customary to mention the money wages agreed between the farmers and ploughmen. Even after that date there were a few years in which no figures for wages were recorded, but the reporters generally indicated the extent of any upward or downward tendency, thus enabling a fairly complete series to be obtained for the period from 1814 to 1870. A range of wages was invariably quoted and these figures have been reproduced in Table 1. The range given for 1814 is based on later references by the reporters to wages at this time.

There are two important points about the data which should be mentioned. First of all, the figures refer to cash wages only, no addition being made for the value of payments in kind, or perquisites. A combination of many factors makes it very difficult to estimate the money value of these perquisites at any one time. They tended to vary in value from farm to farm and according to the age and experience of the ploughmen. Unmarried workers sometimes received their board instead of payments of meal, potatoes and milk. Married ploughmen generally received a free house, garden, meal, the right to graze a cow and the right to grow potatoes on farm land, but during the nineteenth century these last two rights were gradually commuted into payments of milk and potatoes. Apart from this last change, the actual payments in kind in Perthshire do not appear to have altered in any general way during the period under review, but even if an average could be estimated, the problem would still remain of calculating the money value of these perquisites for each year. With so many opportunities for error, an index based on cash wages alone is probably the best possible guide to the movement of earnings. As perquisites were usually consumed directly by the ploughmen and their families, such an index can be taken to indicate the marginal changes which took place in earnings although it tends to exaggerate the extent of any rise or fall in total earnings. It would be wrong, for example, to conclude from Table 1 that earnings doubled from 1817 to 1870. They may have increased by about 50 per cent., but no accurate figure can be given, either in money or "real" terms.

* Similar sources were used by Molland and Evans in their article on farm wages in N.E. Scotland from 1870 to 1900 (Molland & Evans, 1950).

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TABLE 1

Cash Wages of Perthshire Ploughmen, 1814–1870. £ *p.a.*

Year	*Cash Wages*	*Year*	*Cash Wages*	*Year*	*Cash Wages*
1814	**12–16**	1834	**10–11**	1853	15–16
—		1835	**11–12**	1854	18–19
1817	**8–10**	1836	12–15	1855	18–20
1818	**10–11**	1837	..	1856	16–20
1819	10–11	1838	**13–14**	1857	**20–24**
1820	..	1839	12	1858	18–20
1821	10–11	1840	12–15	1859	18–20
1822	10–11	1841	..	1860	18–20
1823	..	1842	12–14	1861	20–23
1824	**11–12**	1843	11–13	1862	18–22
1825	13–14	1844	9–12	1863	19–20
1826	10–12	1845	**12–14**	1864	20–22
1827	11–13	1846	14–16	1865	21–23
1828	10–12	1847	13–16	1866	21–23
1829	10–12	1848	11–13	1867	18–20
1830	11–12	1849	12–14	1868	18–20
1831	11–12	1850	14–15	1869	18–20
1832	10–11	1851	10–12	1870	17–19
1833	..	1852	..		

Notes.— .. no data available; figures in bold type are estimates based on comments by the reporters.
Source.—The Perthshire Courier, October, 1818–1870.

The second point which has to be made about the data in Table 1 is that it is uncertain whether all the figures refer to exactly the same category of ploughmen. The practice commonly followed by the reporters up to about 1850 was to record a lower and higher figure for the wages agreed between farmers and "farm servants" or "ploughmen". No distinction was ever made in the reports between married and unmarried workers, but after 1850 the reporters occasionally recorded wages for several classes of ploughmen, (e.g., first hands, second hands, or third hands), and in other years generally distinguished between "foremen" and "common ploughmen".* It has been assumed that the wages reported for "second hands" or "common ploughmen" are comparable with the wages reported for earlier years in which no differentiation was made.

This lack of consistency in the method of recording the wages, combined with errors which were probably made by the reporters themselves, reduces the value of the data for indicating yearly changes in wages. The main virtue of the material, however, is its continuity over a long period of time, and the absence of a high degree of consistency in the method of recording should not prevent a fairly accurate picture being obtained of long term trends. More confidence of trends over shorter periods would be justified if another source of wage data could be found.

Newspaper reports of hiring fairs held in other parts of central Scotland during this period are unfortunately too scrappy and irregular to be used in a series, even for comparison. As a check on trends during part of the period, however, it is possible to refer to a different source, a collection of account books for the farm of Inchture, in the Carse of Gowrie near Perth, covering the years from 1827 to 1849.

The tenant of Inchture (W. Blyth) kept a separate note each year of the fees or cash wages he agreed to pay to his ploughmen. Table 2 shows the cash wages agreed with workers who remained on Inchture farm for at least four years, and the total cash wages agreed to be paid to the seven regular male workers the farmer employed each year. The persons employed changed frequently, but otherwise the composition of the labour force did not alter very much and the total wages bill is a fairly reliable guide to the general level of cash wages. The wages agreed to be paid to individual ploughmen who stayed a number of years is a useful check, however, showing that a rise or fall in the total wages bill was generally associated with a similar change in the wages of individual workers.†

* In some years the wages of women and boys were also given.

† Part of the agreed "cash" wage was, in practice, paid in kind. The Inchture ploughmen also received the usual perquisites.

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TABLE 2

Cash Wages Agreed to be Paid to Workers on Inchture Farm, 1827–1849. £ *p.a.*

Year	*Ness*	*Duff*	*Buchan*	*Mc-Dougal*	*Todd*	*W'mson*	*Peebles*	*Ogilvie*	*Keilor*	*Total Money Wages**
1827/28	11·0	—	—	—	—	—	10·0	—	—	66·5
1828/29	11·0	—	—	—	—	—	10·3	—	—	72·9
1829/30	11·0	—	—	—	11·6	—	10·3	—	—	69·8
1830/31	12·3	—	—	—	11·6	—	11·0	—	—	69·0
1831/32	—	—	—	—	12·6	—	10·3	—	—	73·1
1832/33	—	—	—	—	—	11·0	10·3	—	—	69·8
1833/34	—	—	—	—	10·5	—	10·3	—	—	74·0
1834/35	—	15·0	—	—	11·6	—	10·3	—	—	76·8
1835/36	—	15·0	—	—	11·0	11·3	—	—	—	74·5
1836/37	—	15·0	—	—	12·6	12·6	—	14·3	—	81·5
1837/38	—	15·0	—	—	12·3	11·6	—	14·3	—	80·1
1838/39	—	15·0	—	—	12·6	12·0	—	14·3	—	82·6
1839/40	—	15·0	—	—	12·3	12·0	—	14·3	—	82·3
1840/41	—	15·0	—	—	12·3	12·0	—	—	—	81·9
1841/42	—	15·0	—	—	12·3	12·0	—	—	13·7	82·4
1842/43	—	13·5	—	—	11·5	11·5	11·3	—	11·0	75·5
1843/44	—	13·5	—	10·0	11·5	11·5	—	—	11·0	71·5
1844/45	—	—	9·5	10·5	11·5	—	—	—	11·0	72·5
1845/46	—	—	12·0	12·0	12·0	—	—	—	—	74·0
1846/47	—	—	15·0	13·3	13·5	—	—	—	—	85·0
1847/48	—	—	15·0	—	15·0†	—	—	—	—	88·1
1848/49	—	—	—	—	15·0†	—	—	—	—	86·4

Notes.—* For seven regular male workers including others not listed here. † Includes £1 7*s.* in lieu of potato ground.

Source.—Inchture Farm Account Books (Blyth MSS.)

A comparison of the Inchture figures and the Perth hiring fair reports tends to support the view that the latter are a fairly good guide to the course of wages in central Scotland. Both sources suggest an increase of roughly 25 per cent. in cash wages from 1827–30 to 1846–49. There is also evidence in both tables of a significant increase about 1836, a decline about 1843 and a rise some three years later. Some of the yearly fluctuations in the hiring fair figures are probably misleading, but the general picture is likely to be as accurate as one can hope for.*

Two questions may now be posed: (1) Can trends in farm wages in Perthshire be taken to be typical of trends in Scotland as a whole? (2) How do the Perthshire figures compare with those for other parts of Britain?

(1) Methods of wage payment in Scottish agriculture in the nineteenth century varied considerably from district to district. In East Lothian and Berwickshire, for example, married ploughmen were often paid all their wages in kind. These perquisites, after being increased between 1790 and 1804, appear to have remained substantially unchanged (in quantity although not perhaps in quality) from the end of the Napoleonic wars until 1860.† On dairy farms in the South-West of Scotland, another method of payment, known as the "bowing system" was generally adopted. The dairy herd was "let" to the byreman, who made a payment in kind to the owner of the herd and retained the surplus produce for his own use or for sale.

In these circumstances it would clearly be unwise to argue that the Perthshire figures of cash wages can be used as a reliable guide to farm workers' earnings in Scotland as a whole. Before any index of "average" earnings in Scottish agriculture can be constructed, detailed regional studies require to be made. The most that can be claimed for the Perthshire material is that it

* Bowley used the following figures for cash wages in Perthshire: Married ploughmen: 1810–13, £12; 1834–43, £12; 1867–70, £23. Unmarried farm servants: 1814, £16; 1834–45, £12½; 1867–70, £20. (Bowley, 1899*a*).

† Report of 1821 Select Committee on Agriculture, evidence of J. Brodie; Report of 1833 Select Committee on Agriculture, evidence of T. Oliver and Professor Low; Robb, J. (1861) *The Cottage, the Bothy and the Kitchen*, Edinburgh, Blackwood, 3–4.

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probably gives a fairly good picture of the general course of wages in most of the counties of central Scotland, (e.g., Angus, Fife, Kinross, Stirling).

(2) Despite the limitations of the figures, it is instructive to compare them with available data for other parts of Britain. This has been done in Diagram 1, in which an index based on Table I is compared with Bowley's index for agricultural earnings in England and Wales. While it needs to be stressed that cash wages in Perthshire are being compared with total earnings in England and Wales, there are a number of interesting points which emerge from the diagram, and which would probably still be valid if more comparable indexes could be used.

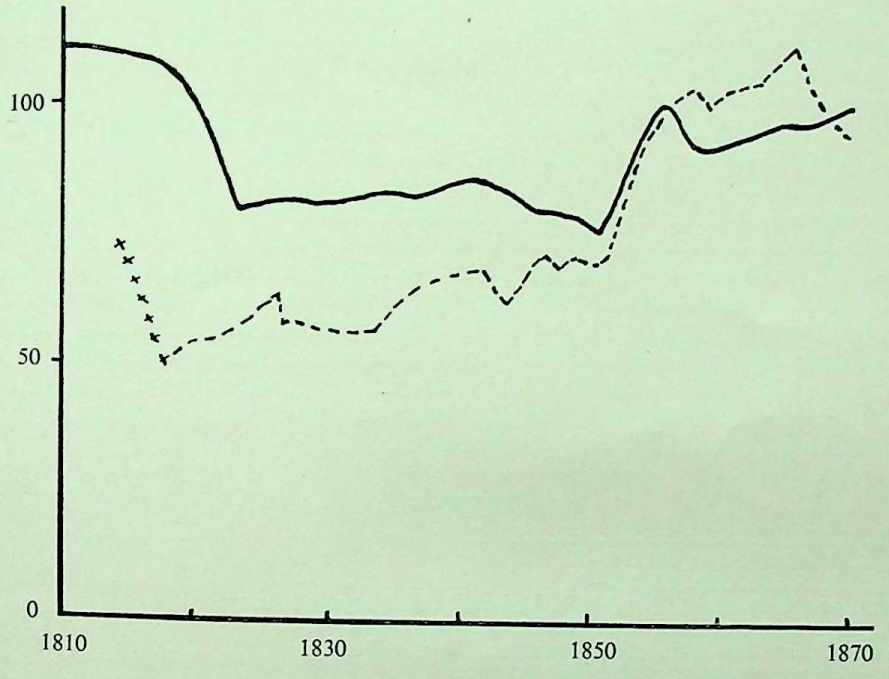


DIAGRAM 1.—Comparison of farm wages in Perthshire and England and Wales, 1814–1870. (1867–70 = 100).

—— Agricultural earnings in England and Wales (3-yearly averages).

- - - Cash wages at Perth hiring fair (3-yearly averages).

xxx Assumes uniform change from 1814 to 1818.

Sources.—Perthshire index from Table 1 (mid-points of ranges). English index from Bowley, 1899*b*.

(*a*) Whereas the post-war decline in earnings in England and Wales continued until the early 1820's, cash wages in Perthshire, after a sharp drop at the end of the Napoleonic Wars, remained fairly steady or rose slightly from 1817 to 1825. This suggests that Bowley was mistaken in superimposing English rates of change on isolated Scottish figures for the period 1814 to 1834. The relatively buoyant tendency in Perthshire wages in the early 1820's is also consistent with the view that at this time the agricultural depression was not so serious in the mixed-farming counties of Scotland as in many parts of England.

(*b*) The level of agricultural earnings in England and Wales in the middle of the nineteenth century was roughly the same as the level 25 years earlier, although the index shows a decline of some 10 points in the 1840's. In contrast, cash wages in Perthshire during the second quarter of the century showed a tendency to rise, and by 1850 they were some 15 points above the level of the early 1830's. It is true that there were economic influences at work in the Perth area (e.g., railway construction in the 1840's) which led to local fluctuations in wages, but, generally speaking,

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it would appear that the over-supply of rural labour which developed in some districts of England was not a feature of central Scotland at this time.

(*c*) In Perthshire, as in England and Wales, the most rapid increase in farm wages took place in the 1850's. This has been called the "golden age" of British farming; it was also the period of the Crimean War and a decade in which emigration from Scotland reached higher figures than ever before.

(*d*) After the Napoleonic Wars there was a marked tendency for wages in Perthshire to rise in relation to earnings in England and Wales. This lends support to a generalization suggested by Bowley's figures, that from 1790 to 1850 Scottish farm wages advanced from a level considerably lower than English wages to a level of approximate parity. Much work needs to be done before such a conclusion can be backed up with detailed evidence on a Scottish scale, but our knowledge of contemporary economic developments in Scotland would certainly lead us to expect a general rise in agricultural wages after 1790.

This was a period in which the industrial revolution gathered pace rapidly, while in the Scottish countryside, especially in mixed-farming districts, there was widespread adoption of methods of farming which required more, not less, labour (the sowing of turnips and temporary grasses, the winter-feeding of cattle, and the use of deep drains and new manures).* As industry has developed in more recent times it has provided the power and machines to replace labour on the land. The main effect of industrialization on agriculture before 1850, however, was not so much to change the technical basis of farming as to change market conditions, and in particular to increase the urban demand for food and labour. With agricultural production expanding, the demand for regular farm workers in most parts of lowland Scotland remained high and fairly stable, while the supply was kept down by the drift to the towns, by the needs of railway and road construction schemes, and, especially about the middle of the century, by emigration abroad. The agricultural situation was, of course, very different in the Highlands, but there were few regular farm workers employed in the North, even in the early nineteenth century.

References

BOWLEY, A. L. (1898), *J. R. Statist. Soc.*, **61**, 702–22.
—— (1899*a*), *J. R. Statist. Soc.*, **62**, 140–50.
—— (1899*b*), *J. R, Statist. Soc.*, **62**, 555–70.
"Inchture farm account books", *Blyth MSS.*, University of Glasgow Library.
MOLLAND, R., & EVANS, G. (1950), *J. R. Statist. Soc. A*, **113**, 220–7.
The Perthshire Courier, 1818–1870, Public Reference Library, Perth.
PURDY, F. (1862), *J. R. Statist. Soc.*, **25**, 425–90.

* An exception (in grain-growing districts) was the introduction of threshing-machines.

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Wholesale Prices in 1954

By the Editor of "The Statist"

Method of Construction of the Index Numbers

The following table illustrates the method of construction of the index numbers. The index numbers here given are based on the average prices for the eleven years 1867–1877. Take, for instance, the *Gazette* price of English wheat:

	s.	*d.*			
Average, 1867–77 . .	54	6,	average point.		
„ 1914 . . .	35	0,	64 or 36 per cent.	*below*	the average point.
„ 1930 . . .	80	7,	148 „ 48 „	*above*	„ „
„ 1936 . . .	53	3,	98 „ 2 „	*below*	„ „

The individual index numbers, therefore, represent simple percentages of the average point. The 45 articles are grouped in six categories. They are shown in detail in Table 5.

The general average is drawn from all 45 descriptions, which are treated as of equal value, and is the simple arithmetic mean.

Table 1

Construction of Index Number for 1954

1867–77 = 100

	Number of Commodities in Index	*Total Numbers*		*Index for 1954*
		1867–77	1954	
General average	45	4,500	16,247	361
Food	19	1,900	6,199	326
Vegetable food	8	800	2,642	330
Animal food	7	700	2,276	325
Sugar, coffee and tea . . .	4	400	1,281	320
Materials	26	2,600	10,048	386
Minerals	7	700	3,331	476
Textiles	8	800	3,434	429
Sundry materials . . .	11	1,100	3,283	298

Table 2

*Annual and Monthly Index Numbers**

1867–77 = 100

	Year	*Jan.*	*Feb.*	*Mar.*	*April*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
1902–1911 .	74	73·9	74·0	74·2	74·5	74·9	74·5	74·5	74·3	74·3	74·5	74·4	74·8
1912–1921 .	148	145·2	146·3	146·9	147·7	147·9	147·2	147·9	149·2	149·0	149·3	149·1	149·2
1922–1931 .	120	122·7	123·0	122·5	122·0	121·0	119·3	119·0	118·0	118·0	118·6	119·2	118·5
1932–1941 .	97	96·0	96·5	96·5	96·8	97·3	96·9	97·5	97·8	98·7	98·8	99·4	101·4
1942–1951 .	231	221·4	224·1	224·6	227·3	228·0	227·1	226·7	227·3	231·2	235·3	238·5	241·2
1943 . .	155	153·3	153·2	154·0	154·9	155·6	155·4	156·0	154·4	154·6	153·7	153·9	153·9
1944 . .	160	154·9	155·1	155·7	157·9	159·5	160·0	161·9	161·5	160·1	159·6	160·3	160·7
1945 . .	164	161·4	161·5	162·1	162·4	164·0	166·7	165·2	163·2	162·7	162·7	162·7	163·2
1946 . .	186	165·6	166·2	166·6	168·4	169·3	169·7	174·4	175·7	180·5	196·2	198·1	200·5
1947 . .	230	206·7	209·6	212·1	215·9	216·5	218·1	223·4	225·9	228·9	236·0	240·8	246·5
1948 . .	260	250·5	253·4	256·0	256·4	260·0	263·9	260·4	260·1	258·1	261·5	263·8	266·0
1949 . .	274	267·6	266·8	265·4	272·0	269·2	267·2	263·3	262·5	285·7	291·5	293·7	297·4
1950 . .	324	300·2	301·0	301·7	305·2	308·3	310·3	317·7	332·1	335·7	349·2	363·1	372·3
1951 . .	402	404·8	420·5	419·3	425·7	420·6	405·2	394·5	387·9	395·9	392·0	396·9	399·7
1952 . .	380	403·5	394·8	384·4	377·5	372·2	379·5	374·4	370·4	369·9	368·9	369·4	372·9
1953 . .	366	374·5	375·2	374·9	370·3	368·1	367·5	361·3	357·9	357·0	357·3	357·7	360·0
1954 . .	361	359·8	361·2	366·1	366·5	363·9	361·2	355·5	353·5	353·7	356·8	362·9	371·7

* The average of the twelve monthly figures of each year does not necessarily coincide with the annual figures, as the latter are calculated mostly from the average of 52 weekly quotations, while the former are based on end-of-the-month prices.

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TABLE 3

Annual and Quarterly Index Numbers for Groups

1867–1877 = 100

	All Groups	Food				Materials			
		Total	Vegetable Food	Animal Food	Sugar, Coffee and tea	Total	Minerals	Textiles	Sundry Materials
1902–1911	74	71	66	88	49	77	90	70	74
1912–1921	148	146	136	167	100	154	166	151	148
1922–1931	120	115	101	150	80	122	137	128	110
1932–1941	97	88	84	116	49	103	131	94	91
1942–1951	231	172	201	169	121	273	300	306	232
1943	155	138	156	156	72	167	187	166	156
1944	160	137	152	156	73	178	197	182	161
1945	164	139	155	156	78	182	209	189	159
1946	186	140	155	154	88	219	239	231	198
1947	230	156	191	149	100	284	304	295	263
1948	260	171	217	155	107	324	368	348	279
1949	274	201	240	185	151	328	382	356	273
1950	324	235	268	204	224	390	416	491	299
1951	402	265	305	227	249	502	516	639	394
1952	380	294	336	285	227	443	532	475	363
1953	366	325	365	317	261	399	473	430	329
1954	361	326	330	325	320	386	476	429	298
1953 1st Quarter	374·9	319·8	372·9	314·6	226·5	415·1	510·6	431·4	342·3
2nd ,,	368·6	331·1	380·9	317·0	250·0	396·0	464·7	430·5	327·3
3rd ,,	358·7	319·2	353·0	317·6	251·9	387·7	453·7	426·8	317·1
4th ,,	358·3	318·7	348·9	315·4	264·4	387·3	459·8	428·8	311·1
1954 1st Quarter	362·4	332·1	354·0	316·3	315·8	384.5	462·7	433·6	299·0
2nd ,,	363·9	332·2	345.7	311·2	342·3	386·9	478·6	429·5	295·0
3rd ,,	354·2	317·7	319·5	332·9	307·8	382·0	480·7	422·4	289·9
4th ,,	363·8	326·6	317·6	339·6	321·7	391·1	491·2	432·2	297·5

TABLE 4

Monthly Index Numbers for Groups

1867–1877 = 100

	Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1953													
Food:													
Total	325	318·1	321·9	319·4	329·8	330·3	333·1	324·4	315·5	317·6	317·3	317·7	321·1
Vegetable food	365	372·7	377·3	368·6	378·5	378·8	385·4	365·3	346·9	346·9	346·1	348·7	351·9
Animal food	317	313·5	314·7	315·7	316·4	317·0	317·5	317·6	317·6	317·7	315·4	315·4	315·4
Sugar, tea and coffee	261	219·6	227·1	232·9	249·8	250·2	250·0	249·8	248·9	257·1	263·1	260·6	269·4
Materials:													
Total	399	415·8	414·1	415·5	399·9	395·6	392·6	388·3	388·9	385·8	386·6	386·7	388·6
Minerals	473	515·7	508·5	507·7	464·5	464·6	465·1	453·5	453·8	453·9	460·3	458·7	460·4
Textiles	430	430·4	431·5	433·2	432·5	430·8	428·2	427·1	432·7	420·6	424·8	428·1	433·5
Sundry	329	341·6	341·5	344·0	335·2	326·2	320·6	318·5	315·8	317·0	312·0	311·0	310·3
1954													
Food:													
Total		328·2	331·6	336·5	334·8	330·7	331·2	329·4	313·9	309.8	314·7	327·8	337·2
Vegetable food		355·9	354·0	352·2	345·1	343·4	348·7	307·0	307·6	302·7	305·6	319·5	327·8
Animal food		315·4	315·4	318·1	318·1	307·7	307·7	343·2	327·0	328·4	332·9	336·0	350·0
Sugar, tea and coffee		295·0	315·1	337·4	343·6	345·7	337·6	328·6	303·3	291·5	301·2	330·0	333·8
Materials:													
Total		382·9	382·9	387·7	389·6	388·0	383·1	377·8	382·5	385·8	387·5	388·6	397·1
Minerals		454·1	459·1	474·9	476·5	478·3	480·9	473·4	478·6	490·2	487·7	481·3	504·5
Textiles		437·5	430·1	433·3	438·2	430·8	419·5	415·3	424·8	427·2	425·8	433·6	437·1
Sundry		297·8	300·1	299·1	291·1	299·5	294·3	289·9	290·6	289·3	295·9	296·9	299·8

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TABLE 5

Average Prices of Each of the 45 Commodities

1949 to 1954

			Average Prices					*Index Numbers* (1866–77 = 100)				
			1950	1951	1952	1953	1954	1950	1951	1952	1953	1954
	Vegetable Food											
1	Wheat, English Gazette	*s.* and *d.* per qr.	110 8	122 10	129 0	138 0	121 0	203	225	237	253	222
2	Man. No. 1 Vanc.	,, ,, ,,	107 9	106 0	108 11	112 5	124 7	192	189	194	200	222
3	Flour, G.R.	*s.* per sack (280 lb.)	52	56⅜	80¾	102⅓	95¼	113	123	175	222	207
4	Barley, English Gazette	*s.* and *d.* per qr.	99 8	124 6	116 4	102 4	91 11	255	319	300	275	236
5	Oats, ,, ,,	,, ,, ,,	60 2	72 11	74 5	68 0	62 10	231	280	286	262	242
6	Maize, American mixed (*a*)	*s.* per qr.	105½	127⅛	132¼	122⅓	114 9/16	325	391	407	376	353
7	Potatoes, good English	,, ton	225	261	295	300	304	192	223	252	257	260
8	Rice, Burma. No. 2*	*s.* and *d.* per cwt.	63 0	69 0	83 6	107 9	90 0	630	690	835	1077	900
	Animal Food											
9	Beef, prime	*d.* per 8 lb.	114	125½	158	176	187	193	213	268	300	317
10	,, middling	,, ,,	96	107½	140	150	170	192	215	280	300	340
11	Mutton, prime	,, ,,	140	152½	190	208	196½	222	242	301	330	312
12	,, middling	,, ,,	98	100	111	113	139	178	182	202	206	253
13	Pork, large and small, average	,, ,,	140	152⅜	190	202	196	269	293	365	389	377
14	Bacon	*s.* per cwt.	175¾	194	281½	339	296	238	262	380	458	400
15	Butter	,, ,,	168¼	230½	250	292½	346	135	184	200	234	277
	Sugar, Coffee and Tea											
16	Sugar, Java floating cargoes (*b*)	,, ,,	40⅜	45⅜	33	26 5/8	26⅛	142	159	116	94	92
17	,, Continental whites	,, ,,	,,	,,	,,	36¼	35 3/16	,,	,,	,,	157	153
18	Coffee, Ceylon plantation, low middling (*c*)	,, ,,	532	520½	471½	448⅝	609	611	598	542	516	700
	Rio, good	,, ,,	297¼	395	380	387	481	464	617	594	604	752
19	Tea, average import price	*d.* per lb.	37·37	39·42	38·36	40·03	54·65	217	228	222	234	310
	Minerals											
20	Iron, Scottish pig	*s.* and *d.* per ton	239 6	252·1	291 10	328 9	344 8					
	Cleveland (Middlesborough) pig	,, ,, ,,	209 1	221·10	255 8	274 10	296 3	348	367	424	468	500
21	bars, common	£ per ton	20	21 7/8	26⅘	28⅜	31¼	244	263	325	344	379
22	Copper, Standard	,, ,,	179	220⅝	260	254⅘	248⅞	239	294	347	340	332
23	Tin, Straits	,, ,,	744⅕	1,073⅞	964 9/16	721 7/16	707 15/16	709	1,023	919	687	670
24	Lead, English pig	,, ,,	111 5/16	163 9/16	135 9/16	91⅗	96⅘	543	798	661	447	472
25	Coal, Best Yorkshire House.†	*s.* per ton	53	58½	64 11/12	69½	62½	241	266	296	316	284
26	average export price	,, ,,	73·65	74·88	94·38	89·03	86·75	589	599	755	712	694

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TABLE 5—*cont.*

			Average Prices					*Index Numbers* (1866–77 = 100)				
			1950	1951	1952	1953	1954	1950	1951	1952	1953	1954
Textiles												
27	Cotton, Middling American	*d.* per lb.	36·15	46·01	38·92	31·83	32·72	402	511	432	354	363
28	East Indian	,, ,,	32·96	42·04	36·93	28·73	32·81	488	623	547	426	486
29	Flax, Medium grade continental retted	£ per ton	351	486	380½	321½	318⅝	689	968	737	628	635
	Belgian import price	,, ,,	296·7	424·3	312·3	269·9	279·4					
30	Hemp, Manila for roping	,, ,,	144	183 7/12	130 15/16	125	92	435	547	527	474	396
	Italian S.B.	,, ,,	195 7/12	243½	270¼	244¾	216¾	593	886	526	417	495
31	Jute, Grade Daisee 2/3	,, ,,	112 7/16	168⅜	99⅞	79¼	94					
32	Wool, Merino, Port Philip, average fleece	*d.* per lb.	157 7/16	177¼	120	126¼	111¼	821	912	621	665	579
	Merino, Adelaide, average greasy	,, ,,	98⅛	106½	73	80¾	69⅛	333	501	251	304	320
33	English Lincoln half hogs	,, ,,	65¾	99	49½	60	63¼	166	162	160	174	160
34	Silk, Japanese	*s.* per lb.	38 5/16	37⅛	36⅔	40	36⅔					
Sundry Materials												
35	Hides, River Plate, dry	*d.* per lb.	28 1/16	42¼	25¼	22 15/16	19⅜	360	558	336	309	281
	River Plate, salted	,, ,,	26 13/16	38 1/16	20 9/16	20¼	19					
	average import price	,, ,,	27·08	47·27	30·96	27·47	25·02					
36	Leather, dressing hides	,, ,,	58	80¾	62½	57	55⅞	373	516	388	380	390
	average import price	,, ,,	71 11/16	98 5/16	72½	75¼	79¾					
	Tallow, Town	*s.* per cwt.	80⅛	109 5/16	86½	66¾	68¼	178	243	192	148	152
	Oil, palm	£ per ton	100 3/16	108⅝	106⅛	83	71¼	257	278	272	213	183
	olive	,, ,,	322	387	328¾	305⅜	263 13/16	644	774	657	611	528
	linseed	,, ,,	132 7/16	169	185	180	80¼	417	522	508	443	292
	Seeds, linseed	*s.* per qr.	243¼	301⅛	272	209¼	182 15/16					
41	Petroleum, motor spirit (c.i.f.)	*d.* per imp. gall.	11·67	12·66	13·30	12·32	12·08	73	80	84	77	76
	Kerosene (burning oil) c.i.f.	,, ,, ,,	10·55	11·41	12·58	11·36	10·87	167	181	199	180	172
	gas oil, c.i.f.	,, ,, ,,	9·84	11·19	11·84	10·76	10·32	247	281	297	270	259
42	Soda, crystals	*s.* per ton	107½	125	190	190	190	117	136	206	206	206
43	Sodium nitrate	*s.* per cwt.	21¾	27⅜	30	29¾	27	155	195	214	212	193
44	Indigo, Bengal, good consuming	*s.* per lb.	7	9⅛	14	12½	12½	97	126	193	172	172
45	Timber, hewn, average import price	*s.* per load	228·33	367·83	376·00	374·64	338·12	534	806	829	758	717
	sawn, or split, average import price	,, ,,	380·46	550·31	569·24	489·49	479·04					

(*a*) La Plata from 1924–40; Argentine (Feeding Stuffs) from 1941–52; La Plata subsequently. (*b*) Raw centrifugals. 96 per cent. Pol., from 1924. (*c*) East India, good middling from 1908–1947; Kenya from 1948. * During war period to mid-July, 1953, quotations represent any description of whole rice under the Rice Order. † Owing to change in selling methods the quotation for house coal alone, no longer ascertainable; the 1954 quotation relates to the average pit price of all grades of Yorkshire coal.

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TABLE 6

Index of Silver Prices

The base of the Index Numbers given below is 60·84*d.* per standard ounce = 100, this being a parity of 1 fine oz. of gold to 15½ standard ozs. of silver.

	Price per oz. Standard (d.)		*Index Number*	
	Average for year	*At end of December*	*Year*	*At end of December*
1942	23½	23½	18·1	18·1
1943	23½	23½	18·1	18·1
1944	23½	23½	18·1	18·1
1945	30½	44	23·1	31·1
1946	48⅝	55½	36·7	41·6
1947	44 7/16	45	33·3	33·8
1948	45	42½	34·1	31·9
1949	49⅕	64	32·8	33·3
1950	64⅘	70	33·7	36·4
1951	77 7/32	77	40·5	40·1
1952	74⅜	72¾	38·7	37·9
1953	73 15/16	73¾	38·5	38·5
1954	73½	74¼	38·4	38·6

TABLE 7

Gold and Silver: Production

	Gold Value of output (£ *thousand*)	*Silver* (*million ounces*)				
		United States	*Mexico*	*Canada*	*Australia*	*Central and South America*
1942	289,153	54·5	84·9	21·8	14·2	31·8
1943	226,397	44·8	71·2	18·6	10·3	29·3
1944	209,031	37·4	63·0	14·8	9·4	29·7
1945	199,116	29·3	61·1	14·0	8·1	27·4
1946	202,435	21·4	48·3	13·6	9·0	26·1
1947	206,434	36·1	49·2	13·5	9·5	23·6
1948	214,647	36·1	45·8	17·0	10·1	23·0
1949	320,887	34·6	49·5	17·6	9·8	24·0
1950	329,580	42·0	49·0	23·2	10·7	28·0
1951	322,623	40·0	43·8	23·1	10·8	29·0
1952	329,381	40·2	50·3	25·2	11·5	32·2
1953	325,500	37·7	47·9	28·3	12·5	34·0
1954*	344,865	37·0	47·0	31·0	12·0	34·0

* Provisional.

(c) Last week, good inferior ... † Owing to change in selling methods the quotation for house coal alone, no longer ascertainable; the 1954 whole rice under the Rice Order. quotation relates to the average pit price of all grades of Yorkshire coal.

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The Sources and Nature of Statistical Information in Special Fields of Statistics

Statistics Available on the Local Government Services

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Contents

	Page
Introduction	234
Financial Statistics	234
Financial Statistics of a General Character	235
Local Government Financial Statistics	235
Return of Rates	236
Miscellaneous Financial Statistics of Counties	236
Financial Statistics relating to Particular Services	237
The "Welfare" services of County Boroughs	237
Fire and Police	237
Housing	238
Financial Statistics relating to Particular Aspects of Local Finance	238
Rating	238
Debt	239
Non-Financial Statistics	240
Ministry of Education	240
Ministry of Health	240
Home Office	241
Ministry of Housing and Local Government	241
Transport	242
Non-Governmental Statistics	242
Statistics of Individual Authorities	243
Summary	243

Previous articles in this series have been concerned with special aspects of local government service, especially those by Benjamin on the Health Service, by Miss Bowley on Housing Statistics and by Miss Lee on Education Statistics. The present article considers the statistical data available in respect of local government services generally and contains certain material additional to that embodied in the three articles before mentioned. An effort has, however, been made to avoid duplication, although to a certain extent it inevitably occurs in an attempt to make these notes as comprehensive as possible.

Financial Statistics

The contents of the various local government financial statistics have been described most comprehensively in a booklet by V. J. Oxley and published in 1951 by the Institute of Public Administration (1). Also an Interdepartmental Committee (2) reported on the available sources of local government financial statistics in 1953. Their Report includes full descriptions of figures collected by the government and refers also to the figures collected and published by other bodies. There is no purpose in re-cataloguing all the detailed information mentioned in these publications, but it is proposed to include brief descriptions of each to make the article complete within itself.

The financial statistics may be divided into two classes:

(*a*) those which deal generally with local government services; and

(*b*) those which deal with specific services or aspects of local government finance.

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Financial Statistics of a General Character

In the first group dealing generally with local government services there is one government publication, *Local Government Financial Statistics*, a booklet prepared by the Rural District Councils' Association and several publications of the Institute of Municipal Treasurers and Accountants and the Society of County Treasurers.

Local Government Financial Statistics (3) is a 16-page pamphlet published annually by the Ministry of Housing and Local Government. It gives a very clear picture of the cost of local services over the country as a whole. The present title of this return has existed since the financial year 1934–35. Before that and going back to the year 1861 returns of "local rates tolls and dues . . . and of the expenditure thereof" were published under the title *Local Taxation Returns*. Even before 1861 spasmodic attempts were made by Members of Parliament and private persons to collect information on the extent of the revenues and expenditures of local authorities or some particular aspect thereof, and many such returns are in the possession of the Ministry of Housing and Local Government, who will be pleased upon application to allow accredited research workers to inspect them. In 1839 a review was made of these earlier efforts in a useful return entitled *Local Taxation* (*Poor Rates*, *County Rates*, *Highways*, *Church Rates*) which in addition to merging the earlier tabulations, pointed out their limitations.

The information contained in *Local Government Financial Statistics* is obtained directly from each local authority in England and Wales by means of questionnaires. The statistics include summary revenue and capital accounts showing the aggregate income and expenditure of all authorities analysed over some twenty main services and a number of subsidiary ones. Other tables in this booklet give aggregate figures for all authorities relating to:

(*a*) Special Funds (Reserve, Insurance, Superannuation).
(*b*) Analysis of Rate Fund Income showing *inter alia* the amount of government grants (specific and non-specific) and the payments in lieu of rates made by the British Electricity Authority and British Transport Commission.
(*c*) Expenditure on salaries and wages—analysed over twelve rate fund services and the trading services.
(*d*) Total income and expenditure analysed over the various classes of local authority.
(*e*) Total income and expenditure for the current and earlier years, going back to 1913.

Thus, within the space of some sixteen pages this valuable little document gives a wealth of information to research workers, accountants and administrators alike A summary of the major aspects of local authority finance may be seen at a glance and comparisons may readily be made between different years: trends may be deduced and policies formulated accordingly. It is fortunate that during this post-war era of rising costs there are available comprehensive data such as these from which may be seen broadly how local revenues are raised and how they are spent. The effect of changes or proposed changes in government policy on local government finance may readily be prejudged and amending legislation the more wisely made. The only regret is that these statistics are not published until some eighteen months after the close of the financial year to which they relate.

It is interesting to note also that although the published statistics show only totals of the expenditure and income of local authorities the working papers with the detailed figures of each authority are available at the Ministry and may be consulted by accredited research workers on application.

The questionnaires upon which Local Government Financial Statistics are based (known as Epitomes of Accounts) are used also for compiling the figures of aggregate income and expenditure of local authorities published in the *Annual Abstract of Statistics* (4). This publication repeats in slightly different form much of the information contained in the Ministry booklet. There are tables in this Annual Abstract for:

(*a*) Income from government grants according to services.
(*b*) Income classified according to source.
(*c*) Expenditure on capital works other than out of loans.
(*d*) Expenditure on capital works.

Comparative figures are available for ten earlier years (including a pre-war year) in each of the tables and in addition there is a corresponding set of tables for Scotland.

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Material from these Epitomes is also used to compile the figures for local authority income and expenditure that appear annually in the White Paper on National Income. In this document a Current Account of Local Authorities is shown quoting income over three headings (rates, grants and profits, etc.) and expenditure over four (current expenditure on goods and services, housing subsidies, grants to persons and debt interest) and current surplus. Figures are quoted for each of the last four years.

Other general financial statistics are published by the Institute of Municipal Treasurers and Accountants, the Society of County Treasurers and the Rural District Councils' Association. Most of these are based upon a tabulated analysis of the data required for the purposes of estimating the current rate for the following year. It follows that the figures contained in these returns are all estimated amounts, but this is no serious drawback as the process of rate estimating by local authorities has been reduced to a fine art and, apart from determining the total levy to be made for the ensuing year, the make-up of the estimates is used during the following year as a means of financial control over that year's expenditure. Thus, estimates and net expenditure may be taken as being almost the same except in very special circumstances.

The Return of Rates and Rates Levied per Head of Population (5) published by the Institute of Municipal Treasurers and Accountants gives an analysis over almost identical headings to those used in the Ministry of Housing and Local Government's *Local Government Financial Statistics*. The first section of this Return shows, in terms of a rate in the £, the expenditure (i.e. gross expenditure including the amounts required to meet the precepts of other bodies, less specific income and specific government grants) for each of these services, together with the income received under the Local Government Act, 1948, Local Taxation Licences and contributions from trading undertakings. The net figure of contributions to or from trading undertakings is also analysed over the various undertakings. The second section shows a similar analysis, but each amount is expressed in terms of rates per head of population instead of rates in the £. Nearly 600 local authorities are represented in this return, including all the metropolitan boroughs and the county boroughs and a large sample of the urban and rural districts and non-county boroughs.

The Return of Rates merges the rates levied by district councils for purely local purposes with those levied to meet the precepts of the county council and other precepting bodies. The amount of each county precept for the main services may however be seen separately in a *Return of Rate Precepts to be Levied by County Councils* (6) published by the Society of County Treasurers. This Return, like the first section of the *Return of Rates*, expresses each amount in terms of a rate in the £, but the Society also publishes a counterpart to the second section of the Return of Rates under the title *Estimated Rate and Grant Borne Expenditure per Head of Population* (7). The latter shows for each administrative county the precepts for the main services expressed as amounts per head of population.

During the course of each financial year the Society also issues a *Miscellaneous Statistical Return* (8) giving general statistics of population, acreage, rateable value (analysed), product of a penny rate, mileage of county roads (analysed), and numbers of children on school registers for each of the administrative counties in England and Wales. At the end of each financial year the Society issues a *Return of General Financial Statistics* (9) which gives a brief summary of the expenditure (actual and not estimated) on rate fund account, specific government grants and grants under the Local Government Act, 1948, net loan debt and the ascertained product of a penny rate.

The Rural District Councils' Association issues each year a *Statement of Rates Levied in Rural Districts of England and Wales* (10). This shows for each of the rural districts general statistics of rateable value, population and product of a penny rate and the division of the rate levied between the R.D.C. general rate and special rate, additional items, county council precepts and other precepts. The return also shows the rateable value per head of population in each rural district

It will be apparent that there is an abundance of information of a general financial character regarding local authorities in England and Wales It is possible to see from the I.M.T.A. and S.C.T. Returns how much most of the larger authorities and many of the smaller ones too, spend individually on their main services, and from the Ministry Returns, how much is spent over the country as a whole on a particular service. The financial statistics of particular services which are described below will show that, in some cases, it is possible to see how the total expenditure is made up on subsidiary services, etc.

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Financial Statistics Relating to Particular Services

Most of the main services administered by counties and county boroughs in England and Wales are the subject of special statistical returns published jointly by the Institute of Municipal Treasurers and Accountants and the Society of County Treasurers. These returns, which are issued in respect of the Children's Service, Education Service, Fire Service, Local Health Services, Police Service and the Welfare Services (11), follow a common form in that they give an analysis of expenditure over the main items expressed (except for Education) as a cost per 1,000 population together with general statistics of population, rateable value and penny rate products, etc., and other statistics relevant to the particular service (e.g. numbers of children). The Children and the Welfare Services returns contain also an analysis of the costs per resident week of maintenance in homes maintained by the local authority. The homes are classified into different sizes and separate figures shown for each class such that it is possible to make comparisons between similar sized homes in different authorities.

The return of Local Health Services statistics shows, in addition to the ordinary analysis of expenditure, unit costs of the various services, e.g. cost per annum per approved place in day nurseries, cost per case attended by midwives, cost per attendance at child welfare centres, etc. Each of these unit costs is divided between "staff" and "other" costs.

The Education return is different from the others in that the analysis of expenditure shown is based upon cost per pupil rather than cost per 1,000 population. In addition to this general analysis of expenditure there is a subsidiary analysis showing costs per meal provided under the school meals service.

These joint returns have only come into being since the war and, relating as they do to new or recently reorganized services, they have not yet quite grown out of the experimental stage, although it is hoped that they are now approaching their final form. Even so, they do give the most accurate information possible on the analysed costs of these services and seek, by expressing these costs on a uniform basis of cost per 1,000 population, to put local authorities on inquiry if their costs are unduly high compared with others. The analyses are for the most part based upon the information required by government departments in their grant claims and it is therefore possible to agree the totals of expenditure with the amounts returned to those departments.

Cost per 1,000 population may be criticized as a unit of cost on several grounds and particularly because it cannot have regard to the composition of the population. Thus some towns, e.g. holiday resorts and spas, may have a high proportion of older people or of children who use the health services more than the ordinary resident adult population. Others may have to cater for a population much greater than the normal resident one (London and the seaside resorts are instances of this class). However, other possible units—e.g. per unit of output, or per member of service, per £ of rateable value, per unit of area (e.g. per 1,000 sq. yds.)—also have their drawbacks. Per unit of output is perhaps the best of these alternatives, but there is not always a convenient unit (e.g. the Fire Service), and even where there is there is not always a reliable record of total units. In one case (Local Health Services Statistics) where numbers of units are available unit costs are used in the I.M.T.A. returns in addition to the population costs. Also, in Police Force Statistics a second unit, in the form of a cost per police officer, is quoted in respect of the total cost. In addition to its general suitability the population basis has the advantage that it directly relates the expenditure to the persons for whose benefit it is incurred, and this personal aspect probably strikes a more realistic note than others might. Thus, a local resident might well reason to himself that it is not right to spend so much *per head* on one aspect of the service, and not so much on another, or alternatively (and also more probably) that the cost *per head* on some other aspect appears outrageously high (or perhaps low) having regard to the possible value of direct benefit which an individual might derive from it.

The unit basis of output is used by the Ministry of Health in their *Ambulance Service Statistics* (12), published for the year 1950–51 and 1951–52 in a separate booklet but henceforth to be incorporated in the Ministry's Annual Report. In these statistics copious data of miles covered, patients carried and vehicles maintained relating to both ambulances and sitting-case cars are given for the directly maintained and agency (Red Cross and St. John) services and costs are expressed per vehicle mile, per patient, and per vehicle. Ambulance costs on a unit basis are likely to be issued from the year 1953–54 onwards jointly by the I.M.T.A. and S.C.T., as the Ministry costs will henceforth not be available until a much later date.

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Yet another return which adopts units of output as its basis is the *Public Cleansing Costing Return* (13) issued by the Ministry of Housing and Local Government. The first post-war return for this service was issued in respect of the year 1952–53 and the last pre-war issue was for 1937–38. The contents include statistics of amounts of house and trade refuse collected per 1,000 population, unit costs of collection and disposal per ton, per 1,000 population and per 1,000 premises. Costs of refuse disposal by the various methods are compared and figures are quoted of income from salvage per ton of refuse collected.

Costs of street and gully cleansing are expressed as a cost per mile per 1,000 gullies cleansed and per 1,000 population, and separate figures of labour and transport costs are given for street sweeping and watering and gully cleansing. Particulars are also given of frequency of cleansing.

Financial statistics of local housing authorities are available in a special return, *Housing Statistics* (14), which is published by the Institute of Municipal Treasurers and Accountants. This covers approximately 500 local authorities of all classes and shows, *inter alia*, the cost of constructing a typical house by each authority during the past year, an analysis of the income of the Housing Repairs Account and an analysis of the income and expenditure on the statutory Housing Revenue Account. There are also particulars given of the rents charged for different types of houses in each authority, numbers of houses completed during the year, total rate subsidy per dwelling and average contributions to the repairs fund.

Financial Statistics Relating to Particular Aspects of Local Finance

Rating

The above relate to statistical returns published in respect of particular services. There are, in addition, returns which relate to particular aspects of local government finance—for example, *Rates and Rateable Values* (15) published by the Ministry of Housing and Local Government. This return is divided into two sections. The first shows for each rating authority in England and Wales the amount of rates in the £, the product of a penny rate, the rateable value and the amount of rates per head of population. This section is all the more interesting for its completeness, covering as it does every rating authority in England and Wales. The second half of the return shows a brief analysis of the rateable value of each administrative county and separate total figures are shown for the non-county boroughs, urban districts and rural districts within each county. The analysis shows separate figures for industrial hereditaments, freight transport hereditaments and other hereditaments, together with a note of the value of property occupied by or on behalf of the Crown for public purposes and upon which contributions in lieu of rates are paid by the government. Other tables in the return give the following information:

(i) Average rate poundages, aggregate penny rate products and average rates *per capita* for the various classes of local authority.

(ii) Aggregate rateable values for the various classes of local authority.

(iii) A frequency table of rates showing the number of authorities within each class levying rates of various magnitudes shown.

(iv) Another frequency table which shows the degrees of variation in rates from one year to another. The numbers of authorities who have increased their rates in the current year compared with the previous year by 30 per cent. or more are shown at the top of the scale above those having smaller increases scaled down to "no change" and decreases up to 15 per cent. or more.

(v) The average rate poundages and aggregate penny rate products and the average rates *per capita* for each of the administrative counties.

(vi) The aggregate produce of rates in England and Wales together with the aggregate rateable value at the beginning of the year, the estimated average rate in the £ levied and the amount actually received by rating authorities. Another figure shown in this table (which is of historical interest as it shows comparative figures for fifteen or sixteen years) is the amount collected per £ of rateable value.

There is a wealth of information in this return, but unfortunately it is not published until some fifteen months after the date (April 1st) to which the information relates.

Analysis of Rateable Value Tables (16).—The Institute of Municipal Treasurers and Accountants and the Society of County Treasurers published as at April 1st, 1952, a far more extensive analysis of rateable value than that given in the Ministry's return. These tables show for each county

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and for each county borough an analysis of the rateable value over the following types of property:

Domestic	Public utility
Commercial	Educational
Licensed premises	Industrial
Entertainment	Miscellaneous

The domestic category is further divided according to magnitude into some nine subdivisions. In addition to the rateable value, the tables also show for each of the above classes of property the total number of hereditaments in each class. A summary table published separately shows the totals in each class for each type of authority in the whole of England and Wales. These tables, published in November, 1953, are the first of their kind to be prepared, the work having been undertaken in view of the impending issue of new valuation lists under the Local Government Act, 1948. It is well known that the issue of these lists has now been postponed until April 1st, 1956, and it is proposed to make a further analysis of rateable value as at March 31st, 1956, immediately before revaluation takes place and again at April 1st, 1957, after the new lists have been issued and appeals thereunder have had time to subside.

Some difficulty was encountered in the preparation of the 1952 tables by the fact that some authorities had not previously analysed their rateable value to the extent required and as a result some estimates had to be made. However, this problem arose mostly in the smaller county districts and fortunately affects the total figures only slightly (about 5 per cent. of the total figures are based upon estimates). No doubt this inquiry will encourage the smaller authorities in future to keep a more detailed analysis and it is hoped that many more authorities will be able to provide actual figures in 1956 than was the case in 1952.

It need hardly be added that the information produced by these analysed returns is invaluable in making estimates of the probable effect of a change in policy on a number of topical local government financial problems, for example, the abolition of de-rating, or the introduction of some form of general exchequer contribution to local authorities other than the equalisation grant under the Local Government Act, 1948. These tables are also of interest indirectly in studying the possible overall effect of the allowable rent increases under the Housing Rents Act, 1954, but care must be taken to remember that the values shown in the tables are rateable values and not gross values to which the tables in the Act refer.

A biennial publication of the Institute of Municipal Treasurers and Accountants deals with *Rate Collection Statistics* (22) and shows for each authority included therein the total number of assessments, particulars of the extent to which owners are rated instead of occupiers, the various compounding allowances and limits applicable, the amount of arrears, Government contributions in lieu of rates and an analysis of the amounts irrecoverable.

Debt

Another return (published biennially) by the Institute of Municipal Treasurers and Accountants is the *Return of Outstanding Debt* (17). This is prepared as at the end of a financial year, i.e. March 31st, and shows the amount of debt outstanding at that date in respect of each of the main trading services, the housing service and the various social services. These amounts are also expressed as amounts per head of population and per £ of rateable value. There is also an analysis showing how the debt has been met, i.e. from stock, mortgages, etc. The average amount of interest paid on the total gross loan debt is also shown. This return does not include all local authorities in England and Wales but all counties, county boroughs and metropolitan boroughs are included and a representative sample of urban districts and non-county boroughs; some 500 authorities in all.

The Stock Exchange Official Year Book (18) is another source of statistics on local authority debt. This book includes a section which quotes in respect of each authority which has issued stock, particulars of each such issue including issue price, redemption dates and prices, mode of transfer, rate of interest and interest dates, together with details of the amount of all other types of debt outstanding, i.e. bonds, P.W.L.B. loans, mortgages and internal loans, at the close of the financial year. (Ranges of interest are quoted in respect of mortgages.) The Year Book has another purely statistical section in which is shown for a number of authorities in the United Kingdom, *inter alia*, total loans outstanding and total capital expenditure on productive and

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non-productive works respectively at the close of the financial year and the surplus of capital assets and outlays over capital liabilities at that date. This statistical section is also published as a separate booklet.

Since 1947 the Ministry of Health and the Ministry of Housing and Local Government have prepared an annual *Return of Capital Payments*. Up to 1950–51 these returns were published in the Annual Report of the Ministry of Health (19) and figures for subsequent years are likely to be published in the Reports of the Ministry of Housing and Local Government. The figures are actually obtained half-yearly and are used for the purpose of central economic planning. It is important, therefore, that the data are well up to date and for this reason some of the figures included are estimated ones and relate to "payments" rather than "expenditure". Particulars are given for the main services and undertakings analysed over acquisition of land and existing buildings; new buildings, works and conversions; vehicles and vessels; plant and machinery; and other capital payments. It is important to note, however, that this return is available a full twelve months before *Local Government Financial Statistics* in which the figures, obtained from a different source, are portrayed more accurately.

The probable extent of current local authority borrowing may be seen from quarterly statements of loans sanctioned prepared by the various Ministries. This information is summarized and published in *Local Government Finance* (20), the official journal of the Institute of Municipal Treasurers and Accountants. The statement is prepared from information supplied by the various sanctioning authorities. This shows for the main non-trading and trading services the volume of loans sanctioned in the preceding quarter, together with corresponding figures for the previous quarter and for the previous year. In considering these figures one must bear in mind that capital expenditure will not necessarily follow the amount of the loan sanctions and in fact will invariably be some way behind the loan sanction. In some cases, owing to a change of plan, the loans sanctioned may never be raised at all. Again, it is important to bear in mind that the sanction is based upon estimated cost, whereas actual cost may turn out to be a very different figure indeed.

The Public Works Loan Board itself publishes an *Annual Report* (21) which contains some interesting total figures relating to local authority borrowing. The classification of services used in the annual report is more extensive than that shown in the quarterly statement referred to above and includes particulars of loan sanctions granted for re-borrowing to repay either stock, mortgages or other securities. The Board's annual report also contains a table showing the amounts actually advanced by the Board during the year. Another table compares the amounts actually advanced by the Board compared with the total borrowings of local authorities. The total borrowing figures are obtained from local government financial statistics and accordingly the figures in this table are very much behind the times. However, now that local authorities are permitted to borrow to a much larger extent outside the Board, later editions of the Board's report should prove most interesting.

OTHER PRINCIPALLY NON-FINANCIAL STATISTICAL RETURNS

Having dealt with all those statistics which are principally financial in character it now remains to examine statistical publications which give other than financial information. The principal items of this type are those published by various Government departments sometimes in the form of annual reports and sometimes in the form of separate booklets.

Ministry of Education

The *Annual Report of the Ministry of Education* (23) contains over 100 pages of statistics relating to all aspects of the service. An account of this publication has been given in Miss Doris Lee's article on the Statistics of Education.

Ministry of Health

As mentioned earlier, the *Ministry of Health* also issues an *Annual Report* (19). This document, which runs to about 165 pages, is, of course, concerned with all Health services and not only those administered by the local authority. There are statistics for the domiciliary midwifery service, statistics giving attendances at ante-natal and post-natal clinics and attendances at Child Welfare clinics, statistics of the attendances at day nurseries, the number of health visitors, the administration of the home nursing service and a summary table of local authorities' expenditure.

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There is also a considerable amount of descriptive narrative matter. In addition to these tables that occur from time to time in the text, there is an appendix which gives details of the local health authorities' arrangements for the care of mothers and young children at ante-natal and post-natal clinics and at Child Welfare centres, showing the number of cases catered for in each way. Other tables give statistics of mental defectives and of persons resident and temporarily resident in premises provided under Part III of the National Assistance Act, 1948, and of numbers of registered blind persons and the nature of their employment.

The Ministry of Health also co-operates with the British Waterworks Association in the production of the *British Waterworks Directory* (24) (formerly the *British Waterworks Year Book*) and this contains statistics of annual charges, particulars of the daily quantity of water supplied, sources of supply, filtration and distribution together with an analysis of the accounts of municipal undertakings.

Home Office

The Home Office publishes annually the *Report of the Chief Inspector of Fire Services* (25). This is a comparatively small document, which runs to only about twenty pages, and is in the main concerned with a description of the work done during the year. There are included in the narrative statistics of the establishments and actual strengths of the fire brigade, the number of personnel taking examinations, disciplinary statistics, fire and operational statistics and details of the various types of appliances and plant owned by fire authorities. There are also other minor statistics on different facets of the service's work, but the only major table and the only one which gives figures for all authorities individually is an analysis of the whole-time and part-time strength of the Brigade analysed between men and women, and giving a comparison of the actual strength with the establishment of each authority. There are also some supplementary statistics for the Ambulance Services.

The Home Office also publishes an Annual Return, *Children in the Care of Local Authorities* (26), giving details of the children in care of local authorities in England and Wales. This small return, unlike the Fire Service return, is almost wholly devoted to statistics. Tables give a detailed analysis of the manner of accommodation of the children in care (divided between the various types of accommodation which can be provided); the age groups of the children in care; the reasons why children came into care during the previous twelve months; the age group on coming into care and the reasons why children went out of care during the previous twelve months, analysed in each case between boys and girls. There is then given a table which shows for each authority in England and Wales the number of children in care, the percentage boarded out and the number of children in care per thousand of population under the age of eighteen in the area. This table is extremely interesting and the different percentages of children in care per 1,000 population in various parts of the country might provide interesting research material for the sociologist. The last table in this return gives details of the expenditure of all local authorities in total on the various types of accommodation, the number of children accommodated, and the cost per child week.

Another Home Office publication is the *Annual Report of H.M. Inspectors of Constabulary* (27) which concerns the Police Service. Tables at the end of this Report give comprehensive statistics on the strength of each Police Force in England and Wales and also derived figures of population and acreage per man. Within the narrative of the Report many other figures covering a variety of matters are given, e.g. crimes known to the police with reference to different types of crime, road accidents, housing of personnel and recruitment.

Ministry of Housing and Local Government

The Ministry of Housing and Local Government publishes a quarterly *Housing Return for England and Wales* (28) which gives comprehensive data on the provision of housing accommodation by local authorities (and by others) in the previous year. Separate figures are given for new permanent and temporary houses and conversion and adaptation of existing premises, and these are arranged in a variety of ways to show by whom they are built and in what region and/or local authority (urban or rural) area, or development corporation. The information relating to each local authority is shown in Appendix B, which is published separately. Appendix A of this return includes summary tables showing in comparative forms the total numbers of dwellings and family units of occupation provided of the various categories of accommodation each year since

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the war, together with details of the comparative rates of building progress over this period by reference to the numbers of tenders approved, cases where construction was and was not begun during the period, completions during the period and the numbers under construction at the end of the period. The Ministry return also gives figures of the various types of permanent non-traditional built houses at various stages of development; accommodation provided in requisitioned properties and in service camps, and houses let to coal miners and agricultural workers, and there are also estimated figures of the housing labour force.

It is not possible in the limited space available to describe fully the information contained in this document, but it is hoped that the items mentioned will give an indication of the wealth of non-financial statistical information available in this comprehensive return.

In addition to the quarterly return the Ministry publishes a monthly Housing Summary (29) for each of the first two months of each quarter showing the total number of post-war houses completed by various agencies in England and Wales.

Other figures which are collected by the Ministry but are not published include a *Statement of Housebuilding Costs* with particulars of tender prices, final costs, site and development costs on a national and regional basis. Another unpublished return gives information about the advances made under the Small Dwellings Acquisition Acts and the Housing Acts for the acquisition, construction, conversion and improvement of houses and the number of houses demolished, closed and made fit under the provisions of the Housing Act, 1936.

The Ministry of Housing and Local Government also collects statistics relating to the annual progress of water supply and sewerage schemes including particulars of work actually done, the labour involved, costs and Exchequer Grant. These figures were formerly published in the Annual Report of the Ministry of Health and in the future will no doubt appear in the Report of the Ministry of Housing and Local Government.

Ministry of Transport

Statistical information on highways expenditure, costs of maintenance, repairs, minor and major improvements, new construction, cleansing, etc., is to be found in the *Report on the Administration of the Road Fund* (30) which has been published annually since 1920.

Statistics of *public transport undertakings* are published by the Ministry of Transport in its *Inland Public Road Passenger Transport Statistics* (34), which gives particulars of bus, coach, tramway and trolley bus undertakings showing numbers of public service vehicles owned, passengers carried and vehicle miles run. These figures have been published since 1931, and up to 1938 were included in an appendix to the *Annual Reports of the Licensing Authorities for Public Service Vehicles* (35).

Non-Governmental Statistics

Statistics of the Library service were formerly given in the *Libraries, Museums and Art Galleries Year Book* (31) published for the Library Association, but the last edition was for 1948. This gives information on the number of volumes in stock, number of the years' issues, tickets in use and reading room attendance and some financial information. The Library Association has also published a statistical booklet for 1952–53 which gives statistics of issues, staff, and an analysis of expenditure for nearly 600 public (rate supported) libraries in Great Britain and Northern Ireland (32).

Similar statistics of the Library service are also published in the *Municipal Year Book* (33). This book also contains statistics relating to a number of other services and in particular to Baths and Washhouses, Parks and Water Supply.

In respect of the last, there are financial details of the total expenditure on the service, the total incumbent expenditure for the year, together with the surplus or deficit, and the total yearly supply in millions of gallons. For Baths and Washhouses there are the details of the number of covered baths, the number of open-air baths, the estimated expenditure and income for the year and the number of persons paying for admission to covered baths, open-air baths, slipper baths, medical baths and washhouses respectively. For Parks and Open Spaces, statistics are given of the total acreage of public open spaces under the control of the authority, the total acreage of public open spaces in the area of the authority, the proportion of total acreage and area of the

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authority per 1,000 population, the gross cost for the year, the net annual cost and the charge to rates.

Statistics of Individual Authorities

Other statistics are published by local authorities themselves usually as part of their abstracts of accounts, but sometimes (particularly in the case of some of the larger authorities) either as separate booklets or combined with a summary of accounts. These statistics vary in nature and extent and are of limited use in national research as they relate only to the area of the local authority concerned.

Statistics published as part of the abstract of accounts are usually quite brief and are really intended as a supplement to the accounts. Figures normally shown in these documents include various tables which relate such factors as the population, rateable value, number of hereditaments and area, etc., one with another. There is usually also included a graphic breakdown of the total rate levy over the services. In addition, some authorities include unit costs of various services and statistics of user. In this respect it is interesting to note that the Institute of Municipal Treasurers and Accountants which is shortly to publish revised recommendations on the Form of Published Accounts of Local Authorities is to include a chapter dealing with unit costs and general statistics. This chapter will give a list of unit costs and general statistics for each service which it is considered might be included in the abstract of accounts or in a separately published summary of accounts.

Separately published statistics are usually far more comprehensive in nature than those included in a bulky abstract of accounts and although necessarily limited to a local authority's own area it must be remembered that in some cases, e.g. the administrative counties (many of whom do issue separate booklets), this area can be quite extensive. The pioneer in this field is undoubtedly the London County Council, which publishes a mass of individual statistics and a statistical abstract. This comprises 120 pages which contain comprehensive statistics on almost anything affecting the London County Council area. There are full analyses of medical statistics for births, deaths and illnesses, statistics relating to London electoral areas, statistics for petty sessional divisions, rateable value and debt, and the following individual services: Ambulance; Education; Health; Housing; Markets; Mental Disorders; Poor Relief; Restaurants and Catering. The return also includes statistics relating to the City of London and the Metropolitan Boroughs.

Although pride of place must go to the London County Council Abstract of Statistics there are a number of other authorities who have adopted a similar practice. The City of Birmingham publishes a separate abstract and so also do many of the administrative counties. A growing popular practice is for authorities to issue an Epitome of Accounts to present details of their accounts in an abridged and easily understood form and in these epitomes there are very often included many statistics of local interest.

There are also the annual reports issued by the local Medical Officers of Health in the counties and county boroughs. These contain a great deal of valuable information, but as Mr. Benjamin's admirable article in this *Journal* in 1949 made special reference to statistics of this type there is no point in dealing with them again here.

Summary

It will be evident from the previous pages that there is an ample supply of financial statistics on local services; all the major services are well covered with detailed figures and aggregate statistics are available for the minor ones. The position is not quite so satisfactory in the case of the non-financial statistics although many valuable figures are available in respect of the more important services, particularly in the publications of the government departments. Perhaps the greatest difficulty in the case of the other non-financial statistics is the form in which they are published—mostly in reports of individual authorities or their officers, and little or no attempt is made to collect these together into one publication; indeed, the figures published are not necessarily of such a uniform nature as to make this possible. However, if the researcher likes to delve far enough he can usually find more or less what he wants, and possibly the preceding pages will assist him in knowing where to look.

This review of statistical information cannot unfortunately be claimed to be complete, particularly regarding the non-financial statistics. There are so many associations connected with

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local authorities which from time to time publish statistics on the service or services in which they are interested that it would be a well nigh impossible task to cover them all. Every effort has been made to mention the more important of these, however, and in respect of others which may be available the reader is referred to the *Municipal Year Book* which gives a comprehensive list of the names and addresses of the Secretaries of the various associations to whom direct inquiries may be made by those interested.

Bibliography

(1) OXLEY, V. J. (1951), *Local Government Financial Statistics*. London: Allen & Unwin. 7*s*. 6*d*.
(2) Interdepartmental Committee on Social and Economic Research (1953). *Local Government Statistics*. Guides to Official Sources 3. London: H.M.S.O. 1*s*. 6*d*.
(3) Ministry of Housing and Local Government (1953). *Local Government Financial Statistics England and Wales*. London: H.M.S.O. 9*d*.
(4) Central Statistical Office. *Annual Abstract of Statistics*. London: H.M.S.O. 21*s*.
(5) *The Return of Rates and Rates Levied per head of Population*. London: Institute of Municipal Treasurers and Accountants. 6*s*. (The 1955–56 and subsequent issues will be 7*s*. 6*d*. each.)
(6) *The Return of Rate Precepts to be levied by County Councils*. Nottingham: Society of County Treasurers. 2*s*.
(7) *Estimated Rate and Grant Borne Expenditure per head of Population*. Nottingham: Society of County Treasurers. 2*s*.
(8) *Miscellaneous Statistical Returns*. Nottingham: Society of County Treasurers. 2*s*.
(9) *Return of General Financial Statistics*. Nottingham: Society of County Treasurers. 2*s*.
(10) *Statement of Rates levied in Rural Districts*. London: Rural District Councils' Association. 2*s*.
(11) *Children Services Statistics; Education Statistics; Fire Services Statistics; Local Health Services Statistics; Police Force Statistics; Welfare Services Statistics*. Published jointly by Institute of Municipal Treasurers and Accountants and Society of County Treasurers. 3*s*. each.
(12) Ministry of Health. *Ambulance Service Statistics*. (1950–51 and 1951–52.) London: H.M.S.O. 4*s*. 3*d*. and 3*s*. 3*d*. respectively.
(13) Ministry of Housing and Local Government. *Public Cleansing Costing Return*. London: H.M.S.O. 3*s*.
(14) *Housing Statistics*. London: Institute of Municipal Treasurers and Accountants Inc. 7*s*. 6*d*.
(15) Ministry of Housing and Local Government. *Rates and Rateable Values*. London: H.M.S.O. 3*s*.
(16) *Analysis of Rateable Values—Counties*. Nottingham: Society of County Treasurers. (1952). 7*s*. 6*d*. *Analysis of Rateable Values—County Boroughs; Summary of Counties and County Boroughs*. London: Institute of Municipal Treasurers and Accountants. 5*s*. and 2*s*. 6*d*. respectively.
(17) *Return of Outstanding Debt*. London: Institute of Municipal Treasurers and Accountants. (Biennial—last issued as at March 31st, 1954.) 5*s*.
(18) *Stock Exchange Official Year Book*. London: Thomas Skinner. 140*s*.
(19) *Report of the Ministry of Health*. Part I. London: H.M.S.O. 5*s*.
(20) *Local Government Finance*. London: Institute of Municipal Treasurers and Accountants. (Monthly.) 52*s*. 6*d*. per annum.
(21) *Annual Report of the Public Works Loan Board*. London: H.M.S.O. 1*s*.
(22) *Rate Collection Statistics*. London: Institute of Municipal Treasurers and Accountants (biennially—last issued for 1952–53). 5*s*.
(23) Ministry of Education. *Education in* 1953. London: H.M.S.O. 6*s*.
(24) *British Waterworks Directory*. (Price and contents vary—last full edition 1936; abridged version 1953; sections of full edition will probably be available for 1954 onwards.)
(25) Home Office. *Report of the Chief Inspector of Fire Services*. London: H.M.S.O. 9*d*.
(26) Home Office. *Children in the Care of Local Authorities*. London: H.M.S.O. 4*d*.
(27) Home Office. *Report of H.M. Inspectors of Constabulary*. London: H.M.S.O. 6*d*.
(28) Ministry of Housing and Local Government. *Housing Return for England and Wales*. London: H.M.S.O. (Quarterly.) 1*s*. 3*d*.
(29) Ministry of Housing and Local Government. *Monthly Housing Summary*. London: H.M.S.O. 2*d*.
(30) Ministry of Transport. *Report on the Administration of the Road Fund*. 2*s*. 6*d*.
(31) *Libraries, Museums and Art Galleries Year Book*. London: James Clark & Co. (Last ed. 1948.)
(32) *Statistics of Public (Rate-supported) Libraries in Great Britain and Northern Ireland*, 1952–53. London: Library Association. 5*s*.
(33) *Municipal Year Book*. The Municipal Journal. 75*s*.
(34) Ministry of Transport. *Public Road Passenger Transport Statistics*. London: H.M.S.O. 1*s*. 3*d*.
(35) Ministry of Transport. *Report of the Licensing Authorities for Public Service Vehicles*. London: H.M.S.O. 6*d*.

Note: Unless otherwise indicated all the above publications are published annually.

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REVIEWS OF STATISTICAL AND ECONOMIC BOOKS

CONTENTS

	PAGE
1.—*Savage* (*L. J.*). The Foundations of Statistics	245
2.—*Festinger* (*L.*) & *Katz* (*D.*) (*Editors*). Research Methods in the Behavioral Sciences	246
3.—*Kempthorne* (*O.*) & others (*Editors*). Statistics and Mathematics in Biology	247
4.—*Gnedenko* (*B. V.*) & *Kolmogorov* (*A. N.*). Limit Distributions for Sums of Independent Random Variables	248
5.—*Booth* (*Andrew D.*). Numerical Methods	249
6.—*Hegeland* (*H.*). The Multiplier Theory	250
7.—*Williams* (*J. D.*). The Compleat Strategyst	250
8.—*Glass* (*D. V.*) & *Grebenik* (*E.*). The Trend and Pattern of Fertility in Great Britain	251
9.—O.E.E.C. Statistics of National Product and Expenditure, 1938, 1947 and 1952	252
10.—*Isaac* (*Julius*). British Post-war Migration	253
11.—*Neisser* (*H.*) & *Modigliani* (*F.*). National Incomes and International Trade	255
12.—*Roll* (*Eric*). A History of Economic Thought. 3rd ed.	256

1.—*The Foundations of Statistics*. By L. J. Savage. Cambridge, Mass.: Harvard Univ. Press, 1954 (London: Geoffrey Cumberlege). xv + 259 pp. 8½″. 40*s*.

Most statisticians still avoid the official and conscious use of one or both of the concepts of utility and probability of a hypothesis. Others, following A. Wald for the most part, use utilities while regarding the probability of a hypothesis as existing but unknown. Statisticians who work for ordinary science may argue that they seek knowledge only, and that their rejection of a hypothesis will not depend on its utility. In industrial applications of statistics this point of view is less defensible, and even in applications to biology, for example, it seems unsatisfactory to many. Savage and others, including the reviewer, consider that the probabilities of hypotheses should normally also be relevant to decisions, even though they can often only be vaguely estimated. Orthodox statisticians aim to convey the indisputable results of experiments in precise numerical terms, leaving it to any one who later uses their work to take into account his own judgments, if any, of the initial probabilities and utilities of the hypotheses. But many users forget to make these judgments and tend to regard a fixed tail-area probability as implying in some sense a fixed degree of provisionality of rejection of the null hypothesis. For this, and for many other reasons, a few statisticians would like the judgments of initial probabilities of hypotheses and of their values (utilities) if true, to be brought explicitly into the theory of statistics. Savage does bring them in, but he does not question the value of orthodox methods, and he considers that the orthodox and unorthodox methods lend each other mutual support and clarification.

The first hundred pages of the book are devoted to the construction and discussion of what the reviewer would call a theory of rational behaviour, i.e. a theory of probability and utility. Probabilities and utilities are introduced simultaneously, following F. P. Ramsey, but with far more attention to detail. The effect is to define the subjective probabilities and utilities for a man in terms of his preferences between acts. The principle of rational behaviour, the recommendation to maximize the mathematical expectation of utilities, is proved by making only the most convincing assumptions. The final theory, though not its method of construction, agrees, for example, with that of the reviewer.* The theory contains a theory of probability agreeing with that of Ramsey, B. de Finetti and B. O. Koopman, in short a theory of (subjective) degrees of belief. This theory, again, includes the ordinary orthodox theory of probability of say Kolmogoroff, but not with the frequentist interpretation, which the non-frequentists think is not operationally expressible except in terms of a non-frequentist theory. Incidentally Savage was originally a frequentist, but has changed his views.

Statistics proper, discussed in the second half of the book, is defined as "the art of dealing with

* (i) *Probability and the Weighing of Evidence* (1950), p. 53; (ii) Rational decisions, *Journ. R. Statist. Soc.*, 1952, *ser*, *B.* **14** 107-14; (iii) Chap. 3 of *Uncertainty and Business Decisions* (edited by C. F. Carter, G. P. Meredith, and G. L. S. Shackle, Liverpool, 1954).

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vagueness and with interpersonal differences in decision situations". The discussion is largely centred on the minimax rule and the "group minimax rule". These two rules are respectively attempts to achieve the two aims of statistics proper, just mentioned. The definitions of the two rules are necessarily technical and will be given here very succinctly.

Let E be an experimental result, where any observations of random numbers used in the design of the experiment, or otherwise, are regarded as part of the experiment itself. Let $f(.)$, a randomized decision function, be a function of E taking values that are decisions to perform certain acts. (To announce that a hypothesis is true is one example of an act.) Let H_i $(i = 1, 2, \ldots)$ be all possible simple statistical hypotheses (so that $P(E \mid H_i)$ is tautologically known) and let j index the members of a group of people (such as a jury). Let $U(f(.), i, j)$ be the expected utility of $f(.)$, given H_i, according to j, before E is observed. Let the "expected regret" be defined by

$$R(f(.), i, j) = \max_{f'(.)} U(f'(.), i, j) - U(f(.), i, j).$$

The rule is to select a randomized decision function $f^*(.)$ such that the maximum possible regret is minimised, i.e.

$$R^* = \max_{i,j} R(f^*(.), i, j) = \min_{f(.)} \max_{i,j} R(f(.), i, j).$$

Suppress j to get the ordinary minimax method, i to get the group minimax method.

The author discusses the conditions under which the minimax rules are reasonable. The reviewer is sorry that minimax rules of type 2 are not discussed. (See reference (ii) mentioned in the footnote to this review.)

The method of randomization in the design of experiments is related to the minimax method on page 216. It is sometimes argued that randomization after an experiment is performed is unjustifiable. Savage denies this (p. 219).

The last three chapters, on point estimation, testing of hypotheses, and interval estimation, cover only 43 pages and seem rather too condensed in view of the title of the book. They nevertheless contain numerous interesting ideas.

Throughout the book "key references" are given, enabling the reader to enter the front lines of research. For example, although there is no discussion of fiducial probability, seventeen references are given. The text contains 288 references to other writers, and the Bibliography contains 172 items of which 142 are dated 1940 or later.

The writing is nearly always lucid, but the book as a whole is difficult to read, largely because of the conciseness of the style. As the author says in the Preface "Serious reading of mathematics is best done sitting bolt upright on a hard chair at a desk. . . . In this book . . . when exercises are indicated, it is absolutely essential that they be read and nearly essential that they be worked, because they constitute part of the exposition . . . ". This then is a book for the practical philosopher rather than the armchair philosopher.

I. J. Good.

2.—*Research Methods in the Behavioral Sciences.* Edited by Leon Festinger and Daniel Katz. London: Staples Press, 1954. xi + 660pp. 8″. 50*s*.

This is a substantial book involving the work of nineteen contributing authors who are psychologists or sociologists connected with the University of Michigan and its Institute for Social Research. The aim of the book is twofold. It seeks to codify research techniques and also to provide graduate students with a guide to work done in the field of social psychology. The plan of the work is clear from section headings and the sequence is logical, including research settings, selecting the sample, collecting the data, analysing the data and applying the findings. In practice behaviour is not investigated in such stages; there is a solitary observation here and an experiment there which confirm that for the social scientist every investigation tends to be unique. The chapters are individual pieces of work which show how difficult it is to reach conclusions about behaviour, and which also emphasize the difficulty of using many authors to make a satisfactory single work.

An example of an excellent piece of work standing by itself is the chapter on selecting the sample. It stands alone because few of the investigations mentioned make use of sample surveys (except for such outside surveys as the population survey carried out by the Bureau of the Census and mentioned as a useful source of information). Many of the reports are about experiments where variability of response is not considered and probability is neither applied nor applicable. Some of the experiments seem indeed to have been undertaken as if investigating in the physical sciences, for there the scientist who converts lead into gold may be justified in crying "Eureka", but when the investigation is in human behaviour the result may simply be an expression of individual freedom or an abnormality.

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The research settings described include, first, field studies without any artificial control, where the interpretation of results will be difficult because the factors one wishes to vary may remain unchanged and there are unsuspected interactions and alien factors associated with other variations. Next, there are field experiments where variations are planned in otherwise natural settings but where it is still difficult to isolate the effects of single factors. Finally, there are laboratory experiments where an attempt is made to control all the factors in a predetermined way and described as an appropriate technique for basic and theoretical research which can produce clear and unambiguous results, adding to the body of knowledge.

To illustrate the approaches to different research settings one example mentioned may be discussed. A field study suggested that rumours in a business were transmitted in a certain direction. As a clearly defined laboratory experiment the problem was described as that of finding "the direction of irrelevant communication in a hierarchy based upon perceived differential importance of the task". In the experiment itself all communication was carried out in writing so that recording and analysis were possible, and, further, in order that only the *perceived* importance of the work differed, all workers were given the same task to do, but one group was told it was important, the other that it was not important. One is sure that such experiments measure something, but cannot help wondering if they seem real to the participants. With experiments on a rat, one assumes the experiments are real to the rat when he is hungry, for it he goes along certain passages he will get food but not if he goes along others. The position is different with persons who know, or may guess, that the situation is artificial. Can one find out how leaders are elected by experiment, especially when the leadership will be nominal or short?

The fourth part of the book contains many interesting suggestions about the analysis of the data, especially when they are qualitative and it is desired to arrange items in order or to a scale. The chapter on distribution-free methods is well worth studying.

To one who is not a psychologist the book is in places difficult to read, as an unfamiliar jargon is sometimes used. As a text-book it is full of suggestions and well documented, and will fulfil its purpose well. As an attempt at coding research techniques it shows that the behavioural sciences need much more experience before this can be done satisfactorily and hence is not very convincing, and one even wonders wherher the approach is along the right lines. Most of the examples come from surveys and experiments in the commercial and industrial field where the object, apparently, has been to get the best out of employees in some particular situation, rather than to generalize about behaviour, whilst the research methods are so diverse that generalizing about them is difficult and the discussion does not go much further than providing a series of hints and tips for questionnaires. This, probably, is all that any book in this subject is justified in doing at the present stage of the development of the science of investigating human behaviour. This work is a valuable summary of investigations and experiments which will help in the ultimate coding of research methods in the behavioural sciences.

H. S. BOOKER.

3.—*Statistics and Mathematics in Biology.* Edited by Oscar Kempthorne, T. A. Bancroft, J. W. Owen and J. L. Lush. Ames, Iowa: Iowa State College Press, 1954. ix + 632 pp. 9″. $6.75.

This is not, as might be hoped from its title, a reasoned and systematic account of the main fields of application of statistical and mathematical methods to biological problems, but an edited collection of papers presented at the Biostatistics Conference held at Iowa State College in 1952, and now published in book form on the ground that they "seemed likely to be of permanent general value". Unfortunately the editors appear to have worked on the principle of not offending any contributor to the Conference: instead of selecting for publication in full only the really suitable papers, they have tried to include all the material presented (except for some papers previously published elsewhere), and have in consequence been obliged to resort to "considerable shortening" in order to keep the size and price of the book within reasonable bounds. (No indication is given of which papers have been shortened, nor of the extent and nature of the cuts, except for a note in Dr. Thomas Park's paper on interspecies competition explaining that the published version "has been reduced by elimination of an introduction originally intended to define what is meant by competition, and to discuss certain steps inherent in its study". This introduction, though not essential to Dr. Park's paper, nevertheless sounds as if it might have been very suitable material for such a book as this—far more so than much actually included—and its omission leaves one wondering how much other useful material has been sacrificed to the ideal of comprehensiveness.) An extremely heterogeneous book results, with some good papers surveying fields of manageable dimensions, others that hurtle breathlessly through enormous areas, and yet others in which small and specialized topics are studied in considerable detail. (Thus, 14 pages are devoted to animal feeding experiments, only 6 to a "survey of experimental design", and 16 to a paper on "The Nucleoproteins in Cell Growth and Division" which is pure biophysics, and seems to earn its place

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in the book only by the inclusion of standard errors in the tables of results.) This sort of mixture makes for stimulating conferences, but rather unsatisfactory books. Most of the papers here included are adequate, though for the most part rather unexciting, but some cover such well-documented ground that there seems no point in their publication, while others, of interest primarily to specialized groups of readers, deserve wider circulation than they are likely to receive in a book as uncertain of its audience as this. Thus one section (on the estimation of populations) contains three good pairs of papers, on sampling human populations, sampling in forest inventory, and sampling mobile populations of animals, all of which would have reached their intended audiences far more successfully had they been published in appropriate technical journals.

The papers are divided into five groups: that mentioned above on population estimation, three other groups on specialized topics (changes in population number, determination of biological response, and the genetical analysis of populations), and a fifth miscellaneous group including all those papers not falling conveniently into any of the special categories. As already noted, some of the papers occur in pairs; this reflects one of the aims of the Conference, which was to bring together " on each of many topics a biologist and a statistician or a mathematician". This scheme has met with varying success. Some of the papers assume rather too great a knowledge of statistical, some of biological, theory for a book presumably intended to appeal both to biologists and to statisticians. Even where this danger is avoided, the "pairing" system has not been uniformly rewarding. In some cases the biologist, instead of presenting the biological problems, has discussed existing statistical methods, but not from a specifically biological viewpoint, thus leaving the statistician with nothing much to do; in others the statistician, instead of answering, or at least discussing, the problems stated by the biologist, has ignored them and discussed some different, though related, topic. Some pairs (the three already mentioned, for example) succeed on the "question-and-answer" basis, or in discussing identical or overlapping topics from different viewpoints (though in most of these cases a collaborative paper would probably have succeeded even better); others succeed not as a pair, but as two good papers on related topics, each of which could stand perfectly well on its own. A good example of this is given by the two papers on interspecies competition; that by Park, mentioned above, on some of his experimental investigations on *Tribolium*, and a discussion by Chin Long Chiang of deterministic and stochastic models appropriate to various modes of competition.

Other good papers are those by Tukey (on the relative merits of correlation and regression methods in interpreting multivariate systems, with particular reference to path analysis—this, easily the most stimulating paper in the book, is one of a pair; the other, by Sewall Wright, gives a survey of the methods and applications of path coefficient analysis, but fails in giving too little account of principles and trying to cover too many applications), and Churchman (an entertaining and provocative discussion of the ethical problems facing the statistician). Less noteworthy, but well worth preserving, are papers by Bliss, on insecticidal assays, and Dews and Berkson, on assays in general, both stressing the existence and importance of large inter-laboratory and even inter-experimental variation (and hence the very limited value of intra-experimental estimates of error), and pairs of papers, by Loosli and Homeyer on animal feeding experiments, by Lush and Crow on the breeding structure of populations, and by Neel and Schull on the organizational problems presented by surveys into the genetic effects of the atomic bombs dropped on Japan.

All references have been combined into a single 40-page bibliography at the end of the book. I found this a little inconvenient at times, and wished for separate reference lists at the end of each paper, but either arrangement has its drawbacks, and presumably considerations of space prevented the inclusion of both.

In spite of its many disadvantages, the book should prove useful to the reasonably instructed and critical reader as a survey of some present-day applications, and deserves its place on the shelves of departmental and institutional libraries. It is, however, likely to prove of very limited value for teaching purposes.

M. R. SAMPFORD.

4.—*Limit Distributions for Sums of Independent Random Variables.* By B. V. Gnedenko and A. N. Kolmogorov. Translated from the Russian and annotated by K. L. Chung. Cambridge, Mass.: Addison-Wesley Publishing Co., 1954. ix + 264 pp. 9″. $7.50.

This is a translation of a book with the same title published in Moscow in 1949. It presents a systematic development of a branch of probability theory that is of considerable importance; as the authors remark "without limit theorems it is impossible to understand the real content of the primary concept of all our sciences—the concept of probability." Since it is written by two masters in the field, since it duplicates the material of no other book, and since it is written in a clear style, it is likely to remain the standard work for a considerable period.

There is a long, and particularly lucid, preface (11 pages) in which the history and nature of the limit theorems of probability are outlined; the apparently anomalous nature of Poisson's

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limit law discussed, and a practical example illustrating the importance of non-normal convergence given.

The first part of the book contains one chapter on probability distributions and random variables. The discussion here goes far beyond that needed in the remainder of the book, where ideas of weak convergence are alone used. In particular the notions of *perfect* and *complete* measures are introduced. The relevance of these ideas to the material in the rest of the book is not at all clear and a helpful appendix, by J. L. Doob, has been included in which this point is discussed. (It would be interesting to see Kolmogorov's appendices to any Russian translation of Doob's work.) The measure-theoretical problems and the concepts of integral are not discussed, but only the results quoted and reference made to a forthcoming book of Kolmogorov's. It is to be hoped that someone can be found willing to translate this work. A second chapter discusses characteristic functions of one-dimensional random variables. (Only the one-dimensional case is mentioned throughout the book.) A third chapter is devoted to the study of infinitely divisible distributions and their canonical representation. Throughout the book, but particularly at this point, the introduction of any important idea is prefaced with a clear outline of the concept, and often an heuristic account of the subsequent development. There are some surprising results on the factorization of distributions.

The second part is devoted to general limit theorems. The method of development is to show that the distribution functions of the sums will approach the distribution functions of the sums of specially constructed infinitely divisible random variables. From the general theorems of this chapter, special results of convergence to the normal, Poisson and Unitary laws (i.e., the weak law of large numbers) are deduced in the next. In the last chapter the special case of cumulative sums is discussed.

The third part specializes still further and identically distributed summands form the topic. Stable laws, domains of attraction, limit theorems for densities, rapidity of convergence to the normal law and limit theorems for lattice distributions are discussed.

The book has been excellently translated. The translator has added many illuminating footnotes and in one place corrected a serious error. He deserves the thanks of English-reading probabilists. The formulae have been printed photographically from the Russian edition; the text has been printed in the usual manner. The result is that the same symbol appears in a different fount in the formulae from that in the text. This causes much less trouble than might be anticipated, and we can all be grateful for the resulting reduction in price.

D. V. LINDLEY.

5.—*Numerical Methods.* By Andrew D. Booth. London: Butterworth's Scientific Publications, 1955. vii + 195 pp. $8\frac{1}{2}''$. 35*s*.

The new era of mathematics opened up by the automatic digital computer has brought forth a renewed demand for treatises designed to bridge the wide gap between the text-books of analysis and the dry instructions for the use of calculating machine operators. Dr. Booth's book, which has arisen from his lectures at Birkbeck College, represents a useful addition to the brief list of modern works in this formerly somewhat neglected field. It has the authority of an expert behind it who can not only put a wide choice of methods before the students, but can tell them also the difference between the efficient and the outdated process. This is the sort of knowledge which is seldom found in text-books, but more often learned from word of mouth or acquired by bitter experience.

If the book has any fault, it is its brevity and condensation, which make some of its sections rather sketchy. The reader can hardly be expected to apply relaxation methods or the Monte Carlo method to the solution of linear equations from the all-too-brief sections 7.7 and 7.12, unless he also refers to the original papers and text-books, which are often as profuse and digressive as the present book is condensed and cryptic. But these are exceptions rather than the rule, and in many fields the student will be well prepared for most practical problems even if he knows nothing more than what Dr. Booth has to say on the subject.

The book is divided into twelve chapters of 7 to 38 pages. After an introductory chapter on the Nature and Purpose of Numerical Analysis, the next four chapters expound Tabulations and Differences, Interpolation, Numerical Differentiation and Integration, and the Summation of Series in a concise and masterly manner. The general reader will be surprised to learn of the small practical value of most of the classical formulae with which he is likely to be acquainted. These chapters will benefit not only those who want to use large automatic computers, but equally or even more those who have nothing more powerful to help them than a desk calculator.

Chapter 6, on the Solution of Ordinary Differential Equations, emphasizes rightly the superiority of the Bashforth-Adams process and its modifications by Milne and by Hartree over the much more widely known but now superseded methods of Picard and Runge-Kutta. (It should be

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mentioned, though, that easy programming has given the Runge-Kutta method renewed popularity with automatic computer operators.) Chapter 7, on Simultaneous Linear Equations, is the longest and contains a wealth of little known material, including the powerful method of von Neumann and Goldstine, yet it is too short for the subject, now 300 years old, which has seen such a surprising revival in the last few years.

The last five chapters, on Partial Differential Equations, Non-linear Algebraic Equations, Approximating Functions, Fourier Synthesis and Analysis, and Integral Equations, also suffer, if anything, from *embarras de richesse*, and the reader will have to refer often to the original literature if he wants to work in these fields. But at least he is likely to have been made aware of almost anything of importance, and nobody could have achieved more in 195 pages than Dr. Booth.

This book must be recommended to all students of physics, mathematics, statistics and econometrics, and also to all those who intend to use digital calculators. No university or research library can afford not to have it on its shelves.

ANDRÉ GABOR.

6.—*The Multiplier Theory*. By H. Hegeland. Lund: C. W. K. Gleerup, 1954. xi + 261 pp. 9¼″. (Lund Social Studies, 9.)

The book opens with an interesting historical chapter on the development of the multiplier idea prior to R. F. Kahn's 1931 article. It is certainly useful to have these precursors on record, particularly as several of them are not well known in English economics. The second chapter deals primarily with Kahn's exposition of the multiplier and also discusses J. M. Clark's approach.

After this comes a group of seven chapters, containing a lengthy critique of Keynes's theory of the multiplier. This is the main part of the book—as the author says, it is intended primarily as "a comprehensive analysis of the methodological problems involved in the multiplier theory". Such a study could be very useful, for the multiplier theory is not only an important theory but one which can be used to illustrate many important points in the methodology of modern economics. Unfortunately, this particular study is rather disappointing.

In the first place—and this criticism applies to the whole book—the exposition is not very clear. This is probably in part due to the author's unfamiliarity with the English language, and though it may seem ungrateful to criticize a man on this score when he has done us the courtesy to write in our language rather than his own, the obscurity remains a defect, and particularly so in a book of this type.

A more important defect is the lack of that balance of judgement that is so important in a critical and methodological work. It is difficult to determine the precise cause of this lack of balance. It may be partly due to the hostility towards Keynes's theory that one senses throughout the book, although one would hesitate to give much weight to so intangible a factor. Or it may spring from a belief that a theory is either right (i.e. exactly and indeed tautologically true) or wrong. There is some evidence for this in the footnote on p. 88, where the speed of convergence of the multiplier series is dismissed as "only of practical importance".

For whatever reason, the author makes no attempt to assess the importance of any particular qualification that must be made to the theory. Where one would have liked a discussion of the probable magnitude of the errors involved in the various aggregations performed, one is merely adjured (p. 73) to dispense with "the habit of dealing with meaningless averages". Where one looks for an assessment of the success of Keynes's ingenious mixture of dynamics and comparative statics, one finds merely the statement (p. 61) that he "tried a logically impossible thing". Dr. Hegeland has compiled a long list of the qualifications that have to be made to the theory, without attempting to distinguish the important from the trivial. Rather, he seems to regard any assumption not strictly satisfied in practice as a reason for "rejecting" the theory.

Chapter ten is entitled "Various Multipliers" and treats impartially of truncated multipliers and related curiosities, and of the large modern literature on matrix multipliers of one sort or another. If the general standard of the book were higher, one would regret that so little space is given to the matrix multipliers for, including as they do inter-industry, international and inter-regional multipliers, they represent one of the more important developments of modern economics. The literature is vast, and the methodological problems of great interest. One would like to know, for instance, how far the ignoring of substitution effects that Keynes found so fertile can validly be carried over into the matrix multipliers.

The book is completed by chapters on the multiplier and the velocity of circulation of money, on the acceleration principle, and on the multiplier and government spending.

M. J. FARRELL.

7.—*The Compleat Strategyst*. By J. D. Williams. New York: McGraw-Hill, 1954. xiii + 234. 9¼″ × 6¼″. 38*s*.

This is an excellent and charming book: so do not be put off by the blurb on the dust-cover, which reads "This primer of game theory can put a mathematical 'ace' up your sleeve. It deals

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with *games of strategy*—so different from games of chance—and shows how . . . to find *the strategy most likely to win.* [Publisher's italics.] . . . The methods are equally useful in games that are played for relaxation in the home, in great earnestness in business, and in deadly seriousness on the battlefield. In fact, any time you find a conflict of interest in the outcome of some event, you'll see a game situation shaping up that can be referred back to the methods in this book. Up to now, the amazing machinery of this field of mathematics has been known only to a handful of experts."

Fortunately, the author takes a much more balanced view of the subject than this. He is a member of the Rand Corporation, and he has made good use of the accumulated experience of that institution in the study of game theory. The book is written for the layman and contains no mathematics at all. This necessarily restricts the treatment, which is confined to two-person zero-sum games with a finite number of strategies for each player. Nevertheless the author not only has managed to convey the general philosophy of game theory, but also has illustrated by way of examples a notable proportion of the techniques available for solving such problems. He is clearly an enthusiast for the subject and expects game theory to play increasingly important rôles in the future; and his intentions are to acquaint the layman with its possibilities. In his introduction he writes: "There should be no illusions: not everybody—even among persons with the desire—is going to be able to formulate and solve difficult problems in this field, for after all it is a very technical subject. But many can learn to handle some problems, and many more can appreciate the possibilities and limitations of the field."

In wholeheartedly recommending this book for layman, pupil, teacher and expert, I need do no more than whet their appetites by the following quotation:

"Example 20. The Bedside Manner.

"The patient is suffering from a well-known disease; so well known, in fact, that five variants, identified with five strains of bacteria, have been observed. Dr. Wendel is quite unable to pin it down from a bedside diagnosis.

"He again feels for the pulse. The patient's confidence goes up one notch, for this re-check is evidence of a careful, conscientious practitioner. The subterfuge would fail and confidence would fall, noisily, if he knew the doctor's reason for the re-check: Dr. Wendel was manufacturing an excuse to look at his second hand; he needed a random number, of course. Which shows that the bases of confidence are very tricky indeed, for the doctor was being super-conscientious and fully deserved the patient's confidence; he just didn't have time to teach him both Medicine and Game Theory.

"The doctor has three medicines: The first has a fifty-fifty chance of overcoming four of the bacteria strains; the second is lethal to one of these four; the third is a fifty-fifty bet against another of these, and it is sure-fire against the fifth strain".

And the author then proceeds to give the game matrix and the appropriate mixed-strategy solutions, both in the absence and in the presence of prior statistical information on relative incidences of the various strains.

The book is decorated by Charles Satterfield's enchanting illustrations.

J. M. HAMMERSLEY.

8.—*The Trend and Pattern of Fertility in Great Britain: A Report on the Family Census of* 1946. By D. V. Glass and E. Grebenik, London: H.M. Stationery Office, 1954. In two volumes: Part I (Report). iii + 306 pp.; Part II (Tables), iv + 253 pp. 13″. £3 10*s.* for the two parts.

Since the Family Census was taken nine years ago, criticisms have been heard of the type and scope of the inquiry decided upon by the Royal Commission on Population. It has been suggested, on the ground of the interdependence of family size and proportion married, that fertility should be measured in relation to all women of whatever marital status rather than to married women and widows alone. The argument has also been advanced that the size of the sample chosen in 1946 was too large, the real need being not for a single investigation but for the study of smaller representative groups at frequent intervals. The very considerable length of time required for the preparation of the Final Report on the Family Census and the fact that its appearance was preceded by the publication of the sample results of the 1951 Census appear to lend support to the second argument. Against this, however, it is evident from the size of the present work that a long and informative monograph on fertility is now available. In studying these concluding volumes of Royal Commission papers it is of special interest, therefore, to consider the extent to which their detailed contents have repaid the time and energy expended and have transcended the limitations of the medium in which the inquiry was cast.

The principal difficulties of fertility censuses, as shown by the British investigation of 1911, are threefold: complexity is almost inevitable in the questions and is likely to be matched by inaccuracy

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in the answers; the analysis of past experience from the statistics of women who have survived to the date of the Census necessarily omits the particulars of non-survivors, whose fertility may well have been different; normally the only useful information obtained relates to families of the last generation rather than of the present generation. In 1946, incompleteness in the response to the questionnaire was a further source of error, but it was possible to correct for this, and there seems little doubt that the Family Census may be classed with the best of its kind in regard to the collection of the available information with as little inaccuracy as possible.

The reason why it is hard to measure current fertility at censal investigations is the impracticability of disentangling the interlocking effects of the three factors: age at marriage, length of time married, and period of calendar years passed through. Much of the difficulty was removed in 1946 by asking women, not only how many children they had had, but also when they had borne them. The additional question, although causing a considerable extension of the tabulations, enabled comparisons to be made of the families of different generations of women at corresponding marriage ages, durations and times. We can now see more clearly that the relative fertility of marriages at different ages has not changed very much in spite of a material fall in family size since 1911. The spacing of births is much the same as it used to be, so that the smaller the family the sooner it is completed. The proportionate differences between the social classes have not greatly altered.

Nevertheless, in an honest and penetrating analysis, the authors are obliged to hedge round their conclusions with many reservations. The making of valid comparisons of marriages of different lengths is hampered by the changing significance of marriage duration as a factor affecting fertility. Social class contrasts are imprecise because differences between classes in age at marriage are just as characteristic as differences in fertility. In summing up the investigation as a whole, one is left with the feeling that while such a full inquiry had perhaps to be attempted it will be a long time before any question of a repetition arises, and in the next few decades the idea of smaller and more frequent samples may predominate.

The Report is well written, and although it is long and complex much has been done by way of lucid explanation to make the reader's task easier. There are several passages that are particularly interesting from the technical point of view, such as the description on p. 87 of the minimal adjustment to family distributions corresponding to given changes in average family size, and there are others which should be of considerable value to students—for instance, the account on p. 97 of the probable effect on fertility of a change in age at marriage. Although most of the data described relate to Great Britain, some separate figures are also given for Scotland.

Nearly 10 per cent. of the data collected related to women whose marriages had ended before they had completed their potentially reproductive life. Apart from a cursory summary, their statistics have remained almost unused. This lack of attention is defended on the ground that measures of reproduction can be based on the experience of women remaining married to age 45, suitably adjusted for losses due to death and divorce. The families of couples where the husband dies or there is a divorce are likely, however, to be abnormally small not only because of the shorter duration of the marriage but also because of incompatibility or ill-health preceding its termination. It would be interesting to know what information the data could have given on this matter.

The constancy of the relative fertilities of different ages at marriage, one of the most remarkable features of recent experience, is hardly given sufficient emphasis in the Report. In present conditions nearly all women have less than five children. It would appear to be possible nowadays for those marrying at age 32 to have as many children as those marrying at age 22, whereas such an equality could hardly have been achieved when much larger families were normal. Nevertheless the average completed family size of those marrying at 32 has remained at only a little over half that of those marrying at 22. If fertile women alone are considered the ratio has risen from just under two-thirds to a little over two-thirds. Even though a study of the most recent experience and of differentials between the social groups perhaps gives some evidence of a loosening of the effect of age at marriage, it is remarkable how little loosening there has actually been.

Now that we have a detailed analysis of the trend of family size over the last forty years, it may be enquired whether we are in a better position than before to foresee the future. Unfortunately, although we can look backwards in the mirror that the authors have provided, all is still misty ahead. Professors Glass and Grebenik have not been able to resist the temptation of estimating the average completed family size of women married in recent years; the assumption is that their future fertility will be the same as that of women who married in 1927. It is to be hoped, however, that the slump and war experienced by that group will not be repeated.

P. R. Cox.

9.—*Statistics of National Product and Expenditure, 1938, 1947 and 1952.* Organization for European Economic Co-operation. Paris: O.E.E.C., 1954. London: H.M.S.O. 310 pp. 4 fol. tabs. $11\frac{3}{4}''$. , 14*s.*

This digest brings together in standardized form the national product and expenditure estimates

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of the O.E.E.C. countries, the series being given both in current and constant prices. Also included are the figures for the two countries co-operating in O.E.E.C., Canada and the United States, and in addition aggregate series have been calculated for the O.E.E.C. countries as a whole and for the group of countries forming the European Coal and Steel Community.

The aim has been to give for each country both domestic and national gross products, with the connecting item of net income from abroad, and the breakdown of national expenditure into public consumption, both military and civil, private consumption and capital formation. Product and expenditure are linked by giving imports and exports, each including factor incomes. The whole account is based on the national product and expenditure account in the O.E.E.C. *Standardized System of Social Accounts*. For this set of series there are tables of the values at current and constant prices, the volume and prices indices, the percentage composition, and volume indices *per capita*. Market prices are used throughout except that the gross domestic product at factor cost is given in current values.

While this has been the target, there are naturally gaps in the series for some countries. No series were available for five countries, but estimates were made to obtain the O.E.E.C. and E.C.S.C. aggregates. The price and volume series are presented with 1951 as the base year. Where the national statistics were not on this basis the series had to be revised by proportional or other adjustment in total; they were not re-worked from the original data.

To obtain all these series on a standard basis and also to make estimates for the missing series, in order to provide the O.E.E.C. and E.C.S.C. aggregates, required extensive calculations and some boldness; but a large part of the book is given up to admirably explicit and clear details of these adjustments and estimates, and of the sources used. The calculation of the O.E.E.C. and E.C.S.C. aggregates made it necessary to net off intra-European trade, and this has yielded as a by-product a set of trade matrices for the O.E.E.C. countries for the years covered.

The standard tables are clearly but a little oddly presented. To show the balance of product and expenditure a grand total is given for each half of the table, but with imports in one half and exports in the other the totals present no meaningful aggregate. The usual method of having exports and imports, with opposite signs, on one side seems more intelligible and less wasteful of space.

This is not the place for a criticism of the Standardized System, but some defect in them is suggested by another unsatisfactory feature of these accounts. Following the product and expenditure account in the Standardized System imports and exports include factor incomes received from and paid abroad, even though net income from abroad appears as well in these tables. As a result imports and exports of goods and services only are not available, and it is not possible to get distinct pictures of the real flows and the financing flows. One has neither the balance in goods and services of domestic expenditure and product as presented in the U.K. official *National Income and Expenditure*, nor is one shown the important financing items of transfers and net investment abroad.

A further consequence is that the distinction between the fairly objective deflation of transactions in goods and services and the essentially arbitrary deflation of factor incomes and other financial items has become slurred over.

It might seem that on these and other points, such as the adherence to market prices, the treatment should have been more strongly supported with reasons. But it should be borne in mind that the O.E.E.C. National Accounts Division have on the stocks an extensive manual on quantity and price measures, a companion to the *Standardized System*, which should discuss these problems at length.

The estimates have been compiled with great thoroughness, and the work is being continued. Revised and up-to-date series are being published in the O.E.E.C. *General Statistics*. This clears up two small points in the text which may perplex British readers. On factor incomes received from and paid abroad the tax paid to the government where the income originates is treated by O.E.E.C. as a transfer to or from abroad; here, for lack of data, only the exports are adjusted to this basis, but series with imports adjusted as well are now given in *General Statistics*. The U.K. population series, and consequently the *per capita* figures, are also to be revised. The series used here does not have the pre-1951 figures revised to agree with the 1951 Census.

These statistics should be widely used in the study of post-war development in Europe, but in using them the margins of uncertainty should be remembered: the errors and shortcomings in the data for each country, the index problems in measurement over time in real terms, and the many problems of international comparisons.

A. A. ADAMS.

10.—*British Post-war Migration*. By Julius Isaac. (N.I.E.S.R. Occasional Paper 17). Cambridge University Press, 1954. xix + 310 pp. 9½″. 30*s*.

After the recent books by Carrier and Jeffery, and Brinley Thomas (both reviewed in this *Journal*) another book on British migration may seem superfluous. The present book, however,

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though covering again part of the ground covered by these authors, particularly as regards the available statistics, their scope and method of compilation, breaks new ground. It is confined solely to the post-war period, mostly the years 1946–1950; it gives a fuller analysis of the official migration statistics than has hitherto been available and it attempts to measure the volume of unrecorded migration and thence to give a balance of total migration for the five years 1946–1950. It also discusses the impact of the war on British migration and the future of British migration policy.

For the official statistics (based on ships' manifests for long sea routes) Dr. Isaac, with the collaboration of the Board of Trade, obtained a 10 per cent. sample of the entries on these manifests of British emigrants for the years 1946 to 1949. These were tabulated by age, sex, type and composition of family, occupation, region of former residence, country of intended residence and class of travel. The occupational classification was specially designed so as "to deduce the socio-economic stratification" of the emigrants, in preference to the one adopted by the Board of Trade—a not very satisfactory one which was discarded in 1951. The tabulations by age and sex show no particular new features; the tabulation by occupation shows that the largest rate of loss by emigration in the period (in proportion to the gainfully occupied) was in the group "professions, proprietors, managers and officials" and the lowest among "unskilled labourers (non-agricultural)". These occupational data are also given by country of intended residence and bring out the "differential occupational selection involved in movements to the various countries of immigration". The tabulations by regions of former residence are new, the Board of Trade returns never having been analysed for this characteristic. Fifteen regions were distinguished and rates of emigration (percentage of the regional population) compiled. The highest rate (1·69) is for the London region, followed by the southern and by Scotland, the lowest rate is for Wales (0·56). Four special chapters are devoted to the receiving countries (Australia, Canada, New Zealand and others) in which the demographic needs, immigration policy and economic conditions are examined in the light of the results of the sample survey supplemented by data compiled by the receiving countries. Owing to the special conditions of the year 1946, when the characteristics of emigrants were much affected by the movement of the so-called "war brides", separate tabulations of the figures are given for this year ("88 per cent. of all emigrants to U.S.A. and 84 per cent. of all emigrants to Canada were, in 1946, members of war-bride families" (p. 61)). This part of the study throws new and valuable light on the nature of British overseas emigration since 1946.

The author then considers the gaps in British migration statistics (i.e. chiefly short sea routes and air traffic). To estimate the volume of *emigration* by these routes, data available from the National Register for 1948 and 1949 are used. These statistics, not formerly published, were made available by the two Registrars-General (they are now given in the study of Carrier and Jeffery cited above). By a series of ingenious estimates and adjustments, Dr. Isaac arrives at the conclusion that *total* emigration in these two years amounted to 511,000 as compared with 321,000 shown by the Board of Trade for overseas emigration. On the basis of this proportion, the emigration other than overseas in the 5-year period is estimated by increasing the overseas figure (769,000) in the same proportion (59·2 per cent. not 52·2 per cent., as stated on p. 206) giving 455,000.

For immigration, the problem of filling the gap is more complicated and the numbers involved are greater than for emigration. The data available for aliens from the publications of the Ministry of Labour, the Home Office and other sources in respect of labour permit holders, resettled Poles, displaced persons, refugees, prisoners of war granted civilian status etc., are exhaustively drawn upon and analysed. "Summing up and rounding off the various guesses and estimates of alien immigration from the Continent, we arrive at the broad figure of 457,000" (p. 191). The remaining gaps are British immigration from the Continent, immigration of Irish, and immigration by air. For the first group the estimate is based on British *emigration* to the Continent, a "reasonable guess" gives 120,000; for the Irish, the British and Irish passenger returns are examined and although these show some marked discrepancies a "best guess" of 125,000 is arrived at; for air traffic, the number of alien immigrants, based on Home Office returns, is estimated as 7,000 and for British immigrants "some statistical evidence which is available for 1949 only" (p. 158) leads to an estimate of 30,000. No margin of error is given for any of these estimates.

Combining the official figures (long sea routes) with the author's estimates given above, a "balance sheet of migration 1946–1950" is given which may be summarized as shown on p. 255.

In view of the approximate nature of many of these figures the net outward balance of 140,000 must be accepted and is so accepted by the author with reservations. The figure subject to the greatest margin of error is that of 455,000 (emigration other than overseas), which, as pointed out above, is based on certain removals from the National Register in 1948 and 1949. The statistics of total passenger arrivals and departures and the statistics of natural increase and estimated actual increase of the population over the five years both show a larger balance. Even if the figure proves too small, the net annual losses from migration in the period are considered by the author to be "insignificant and were probably on the average less than one per thousand of the

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	Immigration	*Emigration*
By long sea routes:		
British	309,000	734,000
Alien	34,000	35,000
By short sea routes:		
British	120,000	
Alien	459,000	
Irish	125,000	
		455,000
By air (extra-European):		
British	30,000	
Alien	7,000	
Total	1,084,000	1,224,000

population a year" (p. 209). In a discussion of future British migration he is of opinion, however, that, allowing for abnormal movements (e.g. of alien immigrants) in the period, "the experience of 1945–50 would indicate an annual net emigration of slightly over 100,000" (p. 229) and argues that a net outward movement of this size, "in spite of some unfavorable demographic effects may on balance be regarded as desirable" (p. 250), whereas the Royal Commission on Population, he infers, "regarded an outflow of this size not only as improbable but also, on balance, as undesirable" (p. 231).

In a final chapter suggestions are made for the improvement of the statistics. For air traffic, at present relatively small, the author finds it "difficult to see why the same procedure (of distinguishing migrants from non-migrants) could not be applied to passengers by air to extra-European countries as to passengers on the long sea routes" (p. 253). To meet the objection that it is impracticable to question all travellers when only about one in ten is likely to be a migrant (total travellers to and from the U.K. in 1946–1950 are given as nearly twenty-five million) he proposes the use of sampling procedures, which have already been tried by the Irish Government in this connection, and are now being applied by the Board of Trade (not yet however to passengers but to the tabulation of the returns of migrants available on the ships' manifests).

It is unfortunate that the book contains not only a number of figures which are obvious misprints and can be corrected by a diligent reader, but also a number of unexplained discrepancies and some errors of calculation and presentation. Space forbids the enumeration of all those noticed by the reviewer, but a few examples are given. The number covered by the 10 per cent. sample is variously given as 59,407 (Table 29) 59,387 (Table 104) 59,393 (deduced from Table 10) and 59,372 (deduced from Table 38). These differences may be due to the fact that for certain tabulations some cards had to be rejected. This does not, however, explain the difference between the two last figures which are of identical tabulations (distribution by size of family). Overseas emigration 1946–1950, 755,200 on p. 32, becomes 750,000 on p. 141 and 760,000 on p. 205; overseas alien emigration, 35,000 on p. 32 and p. 205, is assumed to be 25,000 on p. 141 (first para.). Tables wrongly headed are Table 105 (the figures relate to 1947–1949 not 1946–1949), and Table 87, col. e (where "d" should read "c + d"). Some percentages do not agree with the basic figures (Table 29, col. e, and Table 34, cols. 4 and 5). In Table 76, British emigrants 1946–1950 are added to alien emigrants for 1946–1951. The graphical presentation of certain data, particularly Charts IV, VI to IX, leaves much to be desired. None of these blemishes, however, affects the general conclusions of this book, which is a most valuable contribution to our knowledge of British migration movements since the war, and justifies the statement of Professor Glass in his foreword that "in examining our present needs and in organizing a new programme of collection and analysis of basic data, Dr. Isaac's study will be found indispensable".

J. W. Nixon.

11.—*National Incomes and International Trade: a Quantitative Analysis.* By Hans Neisser and Franco Modigliani. Urbana: University of Illinois Press, 1953. xviii + 369 pp. 10″. $7.50.

In this book, the authors "describe the first systematically developed model of the relations which international trade creates among National Economics". They investigate by econometric methods, the relation between foreign trade and the level of domestic economic activities (as measured by national income, industrial output, etc.), how fluctuations in the level of these activities affect a country's imports and exports and thus its balance of trade and capital movements, and what conditions must be fulfilled by a country's international economic activities (i.e. imports, exports and capital movements) in order to assure a certain level of the domestic economy.

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The period covered is roughly the years 1924–1938. All countries involved in international trade are covered, but in order not to burden the calculations with separate functions for every country they are grouped into six classes, viz. U.K.; U.S.A.; France; Germany; a group of seven other industrial countries (i.e. countries whose exports of manufactured goods were at least half their total exports); and non-industrial countries (i.e. all other countries except the U.S.S.R.); and the trade statistics were grouped into three categories: food, raw materials and manufactures. These data yield thirty-six basic linear equations describing for each of the three commodity categories the import propensities and the export inducements of each of the six groups. Imports of industrial countries are considered as a function of income, imports of non-industrial countries as a function of total exports plus industrial output, and exports as a function of other countries' aggregate imports. The value of the coefficients in these equations is estimated by the application of correlation analyses to the annual data. In Part 2 of the book, these equations are solved for the unknowns, i.e. the import and export magnitudes. The quantitative estimates derived from the model are applied in later chapters to such problems as the interrelationship of business cycles among nations; the financing of the trade balance and the bearing of full employment policies on the balance of payments and the volume of trade.

This investigation, which has taken the authors very many years to complete, is no doubt a valuable contribution to the subject of international economics and the analytical procedures and econometric techniques applied will prove fruitful for further work in this field, but the practical results of the investigation are small and the authors admit that owing to the vast structural changes in the world economy, etc., "it cannot be expected that our coefficients derived from data on the interwar period would be closely applicable to the special conditions obtaining since the end of World War II".

J. W. Nixon.

12.—*A History of Economic Thought.* By Eric Roll. 3rd ed. London: Faber, 1954. 540 pp. 8½″. 30*s*.

Mr. Roll is to be complimented on his courage in embarking at the present time on the formidable task of revising and bringing up to date his *History of Economic Thought* which first appeared in 1938. As he rightly insists, so many things have happened in the last decade and a half both in the world at large and in the field of economic inquiry that a review and revaluation of the history of economic doctrines has become a necessity.

In the theoretical field there has been a widespread adoption of new techniques based in part on new statistical methods. In fact so far-reaching have been the effects of some of these changes in ideas and attitudes—and so ill-digested are some of these changes still to-day—that it may be questioned whether it may not be premature to attempt an appraisal so soon. We live in an age of ferment and transition; many of the newer approaches have hardly emerged from the chrysalis stage and the legitimate deductions to be drawn from them are far from agreed even among experts. But for a book mainly intended for teachers and students an attempted new assessment is perhaps not a bad thing, especially if the writer can avoid the insidious perils of dogmatism and personal prejudice as Mr. Roll so competently does, especially in the latter part of the book devoted to what is sometimes referred to as the "new economics".

Interest in the development of economics is little more than a hundred years old and we have had to wait until the supremacy of the Classical school began to be challenged before interest in earlier thought could be revived.

Besides, the second world war and its aftermath have brought about great changes in the political environment in which economic theories have to be applied, notably a great extension of the scope of State action and a refinement of the means of policy at the disposal of the public authority. To-day there is general acceptance in most advanced Western Communities of the fact that the State has a considerable responsibility for the general level of economic activity and employment. That such acceptance is in no way dependent on a particular political ideology is well shown by the fact that perhaps the most striking example of it is to be found in the predominantly individualistic and largely "unplanned" economy of the United States, "where it is enshrined in a Statute".

Much has also happened to enlarge the scope and improve the methods of co-operation between the countries in which the spirit of liberalism and rationalism continues to flourish.

Curiously enough, despite the extent of its world-sway, modern Communism is scarcely mentioned by Mr. Roll, though the present edition of its book contains in addition to the description of Marx's theories to be found in the first edition—an attempt at an explicit appraisal of them.

Although, as the author explains, there is hardly a page of the original edition which has not had to be altered, this has been done without enlarging appreciably the length of the book or giving it a patched-up appearance; the extra hundred pages or so which have been added are

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to meet the necessity of including new matter to cover such things as the development of American thought, the economics of the inter-war period, the impact of Keynes's *General Theory* on economic and political thinking, and the practical economic policies of the present day. The final chapter describes the spread of Keynesian influence and the reactions to it among economists, business men and politicians. It also includes an all too short outline of the contribution made by modern statistical analysis.

Mr. Roll's main interest is the wider questions of economic scope and method, the relations between economics and politics and the part which economic policy has played in such changes. This explains why more than half the book is devoted to the last hundred years. The author goes out of his way to stress that his book makes no claim to "supplant those encyclopaedic compendia to which teachers and students must necessarily refer from time to time". "The book", he declares, "is concerned only with the main stream of thought which has gone to make up the present day academic theory", in other words with those doctrines which are habitually included in "professional" economics.

It is not surprising, however, that when he comes to deal with the marked change in approach associated with the work of Maynard Keynes he finds it impracticable to keep within the narrow limits of these frontiers. Keynes was not only active as an economist over a wide field but also was prominent as a thinker, teacher and public servant. So much so that prudence suggests that more time will have to be allowed for the dust of controversy to settle before the enduring worth of his contribution to enlightenment can be fairly estimated. It must be conceded that the practice which he brought into fashion of reasoning on the hypothesis of a "closed" economy has done much to lead economists and politicians astray. They have too often been apt to forget that our own economy is far from being "closed" and that to-day—as we have been lately reminded—our main economic problems are those of international trade and international payment, not simply to provide "full" employment by maintaining aggregate demand at an adequate level regardless of whether those employed are engaged in supplying the needs of the home market instead of export trade.

This is not to belittle Keynes's work or influence, but to suggest that they are for the time being perhaps best presented in general terms, such as those used by the late Professor Schumpeter in his monumental, but unfinished, *History of Economic Analysis* which, on a vaster scale, covers part of the same field as Roll's volume. Professor Schumpeter says that Keynes's outstanding contribution was a new "vision". He employs him as an illustration of his personal conviction that "in every scientific venture the thing that comes first is vision". This of course is part and parcel of Schumpeter's ideas on "innovation" as the driving force and germinating principle in practical economic advance. Mr. Roll inclines to a more restrained estimate of Keynes's role. He makes it clear that he dislikes the use of the phrase "new economics" to describe Keynes's contribution. "Such an assessment", he maintains, "is an exaggeration if not a distortion of what has occurred". Nevertheless he affirms that the change in the general climate of opinion compared with inter-war years is very striking. "Keynes exerted an influence on economic theory and policy unequalled since Smith or Ricardo".

Mr. Roll believes that it is no exaggeration to say that the present day is characterized by a powerful trend towards synthesis in economics. He remarks on the existence of "greater occupational mobility among economists and statisticians than ever before". A striking symbol of this coming together of the different schools was the foundation as long ago as 1930 of the Econometric Society. No attempt is made to assess whether statistical or theoretical inquiry deserved most credit for this development, but he has little doubt that statistical advances "have enormously enriched theoretical work". Although barely ten pages are allocated to recent statistical advances they will perhaps suffice to indicate to the non-specialist the extent of the ground covered and the progress made since the book was originally published.

This enlightened and skilfully compiled history of economic thought can be recommended to anyone desiring to obtain, within manageable compass, a general conspectus of the evolution of economic thinking, even if in the end he should come round to what appear to be Mr. Roll's own view that in the event "the 'new political economy' turns out not to be so new after all".

R. GLENDAY.

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STATISTICAL NOTES

(1) British Official Statistics

The interim index of retail prices published by the Ministry of Labour and National Service which was 145 (prices at June 17th, 1947, = 100) in December rose to 146 in January, February and March. In February there was an increase in the general level of clothing prices and in March there were rises in the price of eggs, potatoes and other vegetables. These increases were, however, largely offset by a decline in the prices of butter, cheese, bacon, some kinds of meat and fish. Separate figures on the same basis (i.e., June, 1947 = 100) are not available for the different groups of commodities, but the following are the figures based on January 15th, 1952 = 100.

Date	*Food*	*Rent and Rates*	*Clothing*	*Fuel and Light*	*Household Durable Goods*	*Miscellaneous Goods*	*Services*	*Alcoholic Drinks*	*Tobacco*	*All Services*
Weights:	399	72	98	66	62	44	91	78	90	1,000
Dec. 14th, 1954	118·2	113·2	95·8	114·5	95·1	99·5	112·5	102·6	100·3	109·8
Jan. 18th, 1955	119·2	113·5	95·6	114·9	95·3	99·6	112·6	102·5	100·3	110·2
Feb. 15th, 1955	118·8	113·7	96·3	114·8	95·4	99·7	112·9	102·5	100·3	110·2
Mar. 15th, 1955	118·6	113·9	96·3	114·8	95·4	99·7	113·2	102·5	100·3	110·2

The Ministry of Labour index of weekly wage rates, which was 144 in December (June 30th, 1947 = 100) rose to 146 in January and February and 149 in March. The principal classes of workers whose rates of wages were increased during the period included railway workers, employees in the building and civil engineering industries, engineers and shipbuilders, and workers in retail drapery, food and furnishing and in goods transport by road.

The six-monthly enquiry into average earnings showed that in October, 1954, the average earnings per week in the industries covered by the inquiries were 204*s.* 5*d.* for men, 108*s.* 2*d.* for women, 85*s.* 7*d.* for youths and boys and 69*s.* 5*d.* for girls. These figures represent increases over October, 1938, of 196, 233, 228 and 275 per cent. For all workers combined the average was 171*s.* 9*d.*, an increase of 223 per cent. The index for October, 1954, compared with 100 at April, 1947, was 166. This compares with the weekly wage *rate* index of 145. The average hours worked per week in October, 1954, were 46·7 (48·5 for men only). In manufacturing industries alone the average earnings in October, 1954, were 212*s.* 3*d.* for men, and 108*s.* 11d. for women. The corresponding hourly earnings were 52·5*d.* and 31·1*d.*

The total working population and the numbers in civil employment in the four months ended February, 1955, were as follows:

(*Thousands*)

Date	*Total Working Population*			*Numbers in Civil Employment*		
	Males	*Females*	*Total*	*Males*	*Females*	*Total*
Nov., 1954	16,054	7,856	23,910	15,074	7,744	22,818
Dec., ,,	16,049	7,767	23,816	15,060	7,654	22,714
Jan., 1955	16,077	7,767	23,844	15,076	7,650	22,726
Feb., ,,	16,084	7,768	23,852	15,094	7,651	22,745

The number of persons on the unemployment registers of the Employment Exchanges rose by 41,000 in January and fell by 28,000 in February and March. The total of 269,911 at March, 1955, represented 1·3 per cent of the estimated total of employees in Great Britain. The percentage in the different Regions ranged from 0·5 in the Midlands to 2·3 in the Northern Counties, 2·8 in Scotland and 2·1 in Wales.

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The following is a sex analysis of figures:

Number of Unemployed Persons on the Registers of Employment Exchanges

Date	*Men and Boys*	*Women and Girls*	*Total*
Dec. 6th, 1954	163,351	92,957	256,308
Jan. 10th, 1955	194,697	103,150	297,847
Feb. 14th, ,,	178,977	102,655	281,632
Mar. 14th, ,,	173,615	96,296	269,911

Of the total of 269,911 in March, 70,379 had been unemployed for not more than two weeks, 64,875 for two to eight weeks, and 116,043 for more than eight weeks, while 18,614 were temporarily stopped.

The numbers of insured persons absent from work owing to sickness, including self-employed as well as employed, were 918,700 in mid-December, 1,124,500 in January, 1,072,500 in February and 1,062,600 in March. The numbers of employed persons absent owing to industrial injuries were 55,100, 60,300, 61,500 and 62,200.

Figures published in the *Ministry of Labour Gazette* for February show that the estimated total number of employees in Great Britain at the end of May, 1954, was 21,190,000 (13,840,000 males and 7,350,000 females). These figures showed increases of 120,000 males and 190,000 females compared with a year earlier. The United Kingdom totals for May, 1954, were 14,136,000 males and 7,524,000 females.

The annual report of the National Food Survey Committee (*Domestic Food Consumption and Expenditure*, 1952, Ministry of Food, H.M.S.O., 4*s*.) ranks with the more important Government publications having a direct bearing on living standards in Great Britain. The third report now published follows the lines adopted in 1950 and 1951 and relates to all sections of the population and to each season of the year. The Survey is divided into four main sections: (*a*) Food Supplies and Prices; (*b*) the Household Diet; (*c*) Household Diets of Social Classes; and (*d*) Household Diets and Family Composition. Tables in section (*a*) show the changes in supplies of principal foods between 1950 and 1953 with, for comparison, the position in 1934–38. Supplies per head of population of wheat, butter, fruit and vegetables were on a lower level than pre-war. Supplies of potatoes and milk were greatly increased. Margarine replaced the shortage of butter. 1952 was a year of continual decontrol and of a steady increase in food expenditure which kept in step with average weekly earnings and the general price level. Section (*b*) compares, for each food group, domestic food expenditure by households. The average household diet in each quarter of the year is compared with standards based on the scale of dietary requirements of the British Medical Association and is found to be of adequate nutritional value throughout the year. Section (*c*) provides statistical evidence of the food expenditure by each social class. The classes are divided into four groups according to the income of the head of the household. The distinction between these classes as a whole is fortunately not wide. The Social Class A received per head much more fresh fruit than the average of all households and had a higher consumption of milk, eggs, fresh fish and fresh green vegetables. Section (*d*) confirms earlier studies that household composition, including parents and children, has a greater effect on food expenditure and consumption than social class. The manner in which the sample of households was taken and the degree to which the sample is representative are all important. It is explained in the Appendices to the Report that the method adopted in June, 1951, of selecting by a random method an average per quarter of some 3,000 households in sixty Parliamentary divisions has been continued. The Report is necessarily a compression of a large amount of information, but the basic tabulations of the survey data are being preserved for reference. The care taken in compiling the Survey inspires confidence in the results. With the lessening of official controls, subsequent reports will, as they appear, receive serious study. The work is obviously of national importance.

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(2) Other Statistics

The *Year Book of Labour Statistics*, 1954 (Geneva, I.L.O., 30*s*.) brings together the statistics relating to labour collected by the International Labour Office from sixty-five countries. The data are based on communications to the Office or on official publications. Apart from presenting figures which measure changes over a number of years in various economic activities and which enable certain international comparisons to be made, the Year Book illustrates the extent to which labour statistics have been developed in the various countries. There are, of course, gaps in the information available, but it is evident from a comparison with earlier issues that some of the gaps are gradually being filled. This fact, together with an increasing uniformity in the basis of the statistics, reflects credit on the statistical section of the I.L.O. and on the efforts and recommendations of the periodical conferences of Labour Statisticians. In one set of tables, relating to retail prices, statistics are given for sixty-one of the sixty-five countries. On other subjects the extent of the omissions varies, but thirty countries are represented in more than half of the forty tables in the volume.

The subjects covered by the Year Book include the economically active population, employment and unemployment, hours, wages, retail prices, family living studies, social security, industrial injuries, disputes and migration. Each section is preceded by definitions and indications of the extent to which international comparisons are subject to qualifications. A further precaution against the possible misuse of the figures in making these comparisons is provided in copious footnotes. In most of the tables figures are given for a series of years. So far as available the data relate to two or three pre-war years and to 1947 to 1953, with quarterly figures for the first half of 1954. In many cases, however, material is not available for some of the dates. Where figures are given on an industrial basis, so far as possible use has been made of the International Standard Industrial Classification adopted by the Economic and Social Council of the United Nations, which was only designed a few years ago. Although the use of this Classification appears to be spreading it is clear from the figures in the Year Book that so far many countries have not been able to adopt it in place of differing national arrangements.

The tables relating to the economically active population show the relationship to the total population, an analysis showing employers, employees and unpaid family workers, and the number of employees analysed by industry. In the section relating to employment there are time series of the general level, and also separate indices for the principal divisions of economic activity and for certain important industries. For unemployment indices are given of the general level and also for industrial groups. As regards hours of work there is a time series of average hours actually worked and, in a further table, the normal hours in a number of occupations in October, 1953. The subject of wages is one to which much attention has been given by several Conferences of Labour Statisticians and, with the associated subject of hours of work, is the only branch of labour statistics which has been made the subject of an I.L.O. Convention. A brief summary of the complexities of these statistics is followed, in the Year Book, by a time series of indices of the general level of wages and of the level of earnings in manufacturing industries and other branches of economic activity. These tables are followed by the rates of wages in specified occupations in October, 1953, and a time series of total wages and salaries. Consumer price indices over a period are accompanied by records of retail prices of items of food and certain other consumable commodities in October, 1953. Figures of family expenditure are given for the latest date for which the information was collected in each country. Under the heading of social security figures are given of the number of recipients of each type of benefit together with an analysis of total receipts and expenditure of the schemes. The concluding tables in the volume show the numbers involved and the rates of industrial injuries, the numbers involved and the days lost in industrial disputes and figures of emigrants and immigrants.

The sixth issue of the United Nations *Statistical Yearbook* 1954 (594 pp., $7.50) largely follows the lines of previous issues. A new table on television receivers is included (showing nearly 32 million in the United States and nearly 3·5 million in the United Kingdom out of less than 40 million in the world) and an appendix is reintroduced, after 3 years' absence, showing by subjects the statistics available in the publications (about 50) of international organizations. Several tables have been recast and improved; the most important change is in the one on "value of imports and exports in U.S. dollars" which now gives totals for economic and currency regions instead of for continental divisions.

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The *Annual Bulletin of Transport Statistics* 1953, recently issued by the Transport Division of the Economic Commission for Europe consists of 12 main tables of basic statistics, preceded by a report commenting on the data and illustrated by a large number of additional tables. Each of the four chapters (traffic, networks, mobile equipment, utilization of equipment) is sub-divided into roads; railways; and inland waterways. In this issue, a brief review of transport trends since 1949 and seven special maps of Europe's inland waterways are given. On the last occasion when this bulletin was noticed in this *Journal* (Pt. II, 1951, p. 260) it was stated that "this first Bulletin . . . is capable of much improvement and expansion before it can be said to give an adequate picture of what it calls 'the transport situation in Europe'." This latest issue expanded from 57 pages in 1949 to 132 in 1951 no longer warrants this criticism, though there is still no reference to air transport, to operational statistics such as revenue and expenditure and very little on operational efficiency.

Many of the papers read at the International Conference on Health Statistics held in London in October, 1953, are now published, either in full or in an abridged form, in a special double number of the *Bulletin of the World Health Organization*, 1954, vol. 11. This conference consisted of delegations from the 29 National Committees on Vital and Health Statistics set up as a result of a W.H.O. recommendation in 1948, and was the first of its kind.

On such an occasion it was inevitable that many of the communications consisted of general statements of hopes and aspirations, and there is naturally considerable overlapping among the papers which have been published. On the purely factual level it is particularly useful to have three descriptive papers setting out the present state of vital and health statistics in all the member states of W.H.O. Much of the information is in tabular form, and it is possible to see at a glance that, for instance, statistics of births by duration of marriage are collected in many European countries but nowhere in North or South America. Another table shows that the causes of death are only tabulated for about half that section of the world's population for which W.H.O. has information. It is in the light of such information as this that the papers by Percy Stocks on "Needs in vital and health statistics in underdeveloped countries" and by P. M. Hauser on "The use of sampling for vital registration and vital statistics" should be read. Dr. Stocks suggests the sort of programme that should be adopted by any country with only slightly developed public health and registration systems; in particular he recommends the death-rate of children aged three years and less as a useful local health index. Dr. Hauser discusses the principles governing the use of sampling methods, not only in underdeveloped countries, where basic information may be obtainable in no other way, but also in countries, such as the United Kingdom, with a highly developed system, where such methods enable certain analyses to be carried out more speedily or more economically than would otherwise be possible.

Two papers, from Holland and France, deal with the question of confidentiality in the collection of medical information for statistical purposes; this is a problem which assumes more importance on the Continent than in this country and it is interesting to see a note from Chile explaining that the problem hardly arises in that country. The "public relations" of vital and health statistics are dealt with in two symposia, one dealing with the subject from the point of view of the supplier of the raw material and the other from that of the consumer of the finished article.

From the purely statistical point of view the outstanding paper is that in which F. Fraser Harris describes in detail a survey carried out in Canada in 1950–1 to determine the total morbidity of the country. A complicated design was used to obtain a random stratified sample of about 9,000 dwellings (representing a proportion of approximately 1 : 300 of the population of the country); specially trained enumerators visited these families at monthly intervals over a period of 14 months and diagnoses were checked, wherever possible, by the local doctor. By these means information was obtained, not only on causes of morbidity, but on personal expenditure on doctor's bills, drugs, etc. The total cost of the investigation was estimated to be of the order of $600,000.

A handbook—*Systems of Social Security: United States* (75 c.; 4*s.* 6*d.*)—prepared by the U.S. Government and recently published by the International Labour Office analyses, in five chapters, the legal bases of the various schemes, scope of protection, provision of benefits, and organization and financing. This useful summary brings out the complicated nature of social security in the United States due to the respective competences of the states and the federal government. There are consequently "a myriad of administrative patterns and agencies that together make up the nation's programme". Thus, old-age and survivorship insurance is national, unemployment insurance is state-controlled, and industrial injury insurance is federal-state. Sickness

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insurance (except that due to maternity) exists in a few states only; family allowances are not covered. Benefits are, unlike the British system, usually based on earnings.

A statistical appendix gives only total payments and recipients under the various schemes in 1953. No data are given on, e.g., the numbers covered, or on such subjects as the incidence of unemployment by regions or industries. It is known however (from other sources) that of the total labour force in 1953 of about 62 million, about 48 million were covered by old age, etc., insurance, and about 40 million by unemployment and industrial injury insurance. Those not covered are chiefly employers and many of the self-employed.

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STATISTICAL AND ECONOMIC ARTICLES IN RECENT PERIODICALS

UNITED KINGDOM—

Accounting Research—

January 1955—A note on interest, depreciation and economic choice: *F. E. Nolan.* Accounting dynamics—II: *F. Sewell Bray.* Computers and accounting systems: *R. H. Gregory.* A statistical approach to auditing tests: *I. R. Taylor.*

Annals of Human Genetics—

February 1955—The transformation of discrete variables: *F. N. David.*

British Journal of Preventive and Social Medicine—

October 1954—Old people living in Dorset: A socio-medical survey of private households: *W. H. Simonds* and *A. Stewart.* Premature disablement and death among Post Office workers: the late *C. G. Roberts* and *D. D. Reid.* Prematurity and paid work during pregnancy: *R. Illsley, W. Z. Billewicz* and *A. M. Thomson.* Current differential infantile mortality. England and Wales: *W. Taylor.* A survey of mental hospitals and mental deficiency institutions in the Birmingham region. II. Mental deficiency institutions: *K. W. Cross.* Changing pattern of mortality in England and Wales. II. Maternal mortality: *W. Taylor* and *M. Dauncey.* Comparative fertility in the local government areas of England and Wales, 1951: *W. Taylor.* A note on the sex distribution of sibs: *W. Taylor.* Admissions to Scottish mental hospitals in the last hundred years: *D. Cameron.*

January 1955—Incidence of defects in visual functions in children and adults: *A. Sorsby, B. Benjamin* and *J. Yudkin.* Social medicine studies based on civilian medical board records. I. National service rejects; II. Physical and occupational characteristics of men with varicose conditions: *A. M. Stewart, J. W. Webb* and *D. Hewitt.* Psychiatric disability and employment. I. Survey of 222 registered disabled persons; II. Follow-up of 95 unemployed subjects: *M. Markowe, W. L. Tonge* and *L. E. D. Barber.*

Economica—

February 1955—Industrial production in the United Kingdom, 1900–1953: *T. M. Ridley.* The purchasing power of British exports: *R. L. Marris.* Public departments and cheap money, 1932–38: *D. S. Lees.*

Economic Journal—

December 1954—Social accounting in relation to economic theory: *D. K. Burdett.* The position of economics and economists in the government machine: *R. L. Marris.* Statistical inference in dynamic economic models: *M. R. Fisher.*

Eugenics Review—

January 1955—Some observations on infant mortality in India, 1901–1951: *S. Chandrasekhar.*

Incorporated Statistician—

August 1954—Industrial censuses in the United States: *C. O. George.* Some aspects of medical statistics: *V. Norris.* The Gallup Poll and some of its problems: *H. Durant.*

November 1954—The contiguity ratio and statistical mapping: *R. C. Geary.* Statistics in research and management in the cotton industry: *L. H. C. Tippett.*

Institute of Actuaries Students' Society, Journal—

November 1954—The meaning of probability: *W. Perks.*

Manchester School of Economic and Social Studies—

January 1955—Some results of distribution of industry policy: *J. Sykes.* The prospects of British shipbuilding: *L. Jones.*

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Oxford Economic Papers—

September 1954—Period analysis and inventory cycles: *R. Nurkse*. The price of fuel: *D. L. Munby*. The dollar crisis revisited: *T. Balogh*.

Oxford University Institute of Statistics, Bulletin—

November–December 1954—Labour productivity and size of establishment: *J. Johnston*. A "human needs" diet: autumn 1954: *T. Schulz*. Appendix: "human needs" diet in Northern Ireland: *D. E. Field*. Retail trade, retail prices and real wages in U.S.S.R.: *P. J. D. Wiles*. On the difficulties of measuring wage differentials: *K. G. J. C. Knowles* and *T. P. Hill*.

February 1955—Growth and balance of payments: a symposium. The savings survey 1953: response rates and reliability of data: *T. P. Hill*, *L. R. Klein* and *K. H. Straw*.

AUSTRALIA—

Statistical Society of New South Wales, Bulletin—

September 1954—Characterisation of the normal distribution: *H. O. Lancaster*.

INDIA—

Calcutta Statistical Association Bulletin—

October 1954—Unbiased and biased statistics in the binomial population: *A. Bhattacharya*. A critical survey of some test methods in time series analysis: *A. Rudra*. Statistical training in the United States: *M. N. Ghosh*. The so-called almost balanced incomplete block design: *K. R. Nair*. Relation between canonical correlations and partial canonical correlations: *I. M. Chakravarti*.

UNITED STATES—

American Statistical Association, Journal—

December 1954—Methods of apportioning seats in the house of representatives: *W. F. Willcox*. The Kinsey Report on females: *D. S. Brady*. Unsolved problems of experimental statistics: *J. W. Tukey*. Measures of association for cross classification: *L. A. Goodman* and *W. H. Kruskal*. A test of goodness of fit: *T. W. Anderson* and *D. A. Darling*. Univariate two-population distribution-free discrimination: *D. S. Stoller*. Use of normal probability paper: *H. Chernoff* and *J. Lieberman*. Analysis of simple lattice designs with unequal sets of replications: *P. Meier*. On the presentation of the results of sample surveys as legal evidence: *W. Edwards Deming*. Accuracy of age reporting in the 1950 United States Census: *R. J. Myers*. Validation of morbidity survey data by comparison with hospital records: *N. B. Belloc*. Business failures: another example of the analysis of failure data: *K. S. Lomax*. Cyclical fluctuations in foundry activity: *L. Saville*. Cargo loss in ferrying operations: *W. L. Deemer, Jr*. The experimental approach in the teaching of statistics: *E. G. Olds*. Use of experiments in teaching engineering statistics: *I. W. Burr*.

Annals of Mathematical Statistics—

December 1954—Saddlepoint approximations in statistics: *H. E. Daniels*. A general theory of discrimination when the information about alternative population distributions is based on samples: *C. R. Rao*. A confidence interval for variance components: *J. R. Green*. A simple sequential procedure for testing statistical hypotheses: *C. K. Tsao*. On a contagious distribution: *R. S. G. Rutherford*. Identification and estimation of linear manifolds in n-dimensions: *T. A. Jeeves*. Asymptotic behavior of some rank tests for analysis of variance: *F. C. Andrews*. Multidimensional stochastic approxima-methods: *J. R. Blum*. Certain inequalities in information theory and the Cramér-Rao inequality: *S. Kullback*. Some further results in simultaneous confidence interval estimation: *S. N. Roy*. Tables for the distribution of the number of exceedances: *B. Epstein*. On the factorization of distributions: *H. Teicher*. On the convolution of distributions: *H. Teicher*. Sequential procedures that control the individual probabilities of coming to the various decisions: *L. Weiss*. On a characterization of the gamma distribution: *R. G. Laha*. Matching in paired comparisons: *J. L. Hodges, Jr.* and *E. L. Lehmann*. Note on a theorem of Lionel Weiss: *L. LeCam*. The distribution of distance in a hypersphere: *R. D. Lord*. Extreme values in samples from m-dependent stationary stochastic processes:

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G. S. Watson. Expression of the k-statistics, k_9 and k_{10}, in terms of power sums and sample moments: *M. Zia-ud-Din.* The probability integral of range for samples from a symmetrical unimodal population: *J. H. Cadwell.*

Biometrics—

December 1954—Some methods for strengthening the Common χ^2 Tests: *W. G. Cochran.* Short-cut formulas for the exact partition of χ^2 in contingency tables: *A. W. Kimball.* A note on the χ^2 Test applied to epidemic chains: *J. Almond.* Misclassification in 2×2 tables: *I. Bross.* A 2×2 factorial with paired comparisons: *R. M. Abelson* and *R. A. Bradley.* Some considerations in the design of successive experiments in fruit plantations: *T. N. Hoblyn, S. C. Pearce* and *G. H. Freeman.* Variance heterogeneity in a randomized block design: *F. Graybill.* Some observations on sensitivity and repeatability of triad taste difference tests: *J. W. Hopkins.* The estimation of response-time distributions. III. Truncation and survival: *M. R. Sampford.*

Econometrica—

October 1954—Some basic principles of price of living measurements (a survey article): *R. Freisch.* Rational selection of decision functions: *H. Chernoff.* The consumption of food in relation to household composition and income: *J. A. C. Brown.* The effect of structural matrix errors on interindustry relations estimates: *W. Duane Evans.* Import substitution in Leontief models: *K. J. Arrow.* Linear expenditure functions (an expository article): *R. Frisch.*

Estadística—

December 1954—Statistical bases of traffic accident prevention: *W. C. James.* Accuracy of population projections for the United States: *H. S. Shryock, Jr.*

Industrial Quality Control—

January 1955—Chain sampling inspection plan: *H. F. Dodge.* A survey of the use of statistical methods by ASQC members in the metals industry: *F. G. Norris.*

February 1955—Skip-lot sampling plan: *H. F. Dodge.* Application of quality control in the manufacture of electrical cable: *C. K. Hamlin.* Some notes on the theory and application of rank order statistics, part 1: *R. A. Bradley.*

Mathematical Tables and other Aids to Computation—

October 1954—A generalization of the method of conjugate gradients for solving systems of linear algebraic equations: *J. H. Curtiss.* On the estimation of quadrature errors for analytic functions: *P. Davis* and *P. Rabinowitz.*

Operations Research Society of America, Journal—

February 1955—Observation, experiment, and measurement in operations research: *O. Solandt.* Simulation as an aid in model building: *R. P. Rich.* A proposal for revising New York's subway fare structure: *W. S. Vickrey.* Approximate salvo kill probabilities for small and medium sized targets when cumulative damage is unimportant: *J. E. Walsh.* A statistical guide for accident research, illustrated by application to non-air-carrier flying, 1949–1951: *A. J. Duncan.* A discussion of education for operations research: *A. Schulz, Jr.*

Psychometrika—

March 1955—Sampling fluctuations resulting from the sampling of test items: *F. M. Lord.* Separation of data as a principle in factor analysis: *C. W. Harris.* The choice of an error term in analysis of variance designs: *A. Binder.* A rational curve relating length of rest period and length of subsequent work period for an ergographic experiment: *L. R. Tucker.* A measure of interrelationship for overlapping groups: *B. J. Winer.* An extension of Anderson's solution for the latent structure equations: *W. A. Gibson.* A factor analysis of mental abilities and personality: *J. C. Denton* and *C. W. Taylor.* A tabular method of obtaining tetrachoric r with median-cut variables: *G. S. Welsh.* An IBM method for computing intraserial correlations: *M. C. Payne* and *L. Staugas.*

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Quarterly Journal of Economics—

November 1954—Irrationality in economics: *L. Baudin.* Random variations, risk, and returns to scale: *T. M. Whitin* and *M. H. Peston.* Information, risk, ignorance and indeterminacy: *M. Shubik.*

Review of Economics and Statistics—

February 1955—Exchange rate adjustment and relative size of the depreciating bloc: *G. H. Orcutt.* The matrix as a tool in macro-accounting: *E. Fuerst.* Age, labor force and state per capita incomes, 1930, 1940, and 1950: *F. A. Hanna.*

FRANCE—

Revue de Statistique Appliquée—

Vol. II, No. 3—Principes fondamentaux de la méthode statistique et applications industrielles: *J. Mothes.* Comparaison des moyennes de deux populations normales d'écarts-types inconnus et différents: *G. Darmois.* Sur la construction d'intervalles de confiance pour la proportion de défectueux d'un lot à partir d'échantillons d'effectif peu élevé: *Mme. Cassignol.* Méthode statistique d'évaluation des temps opérationnels (avec application à l'industrie de la fonderie): *J. Moriceau.* Détermination du rendement du matériel de râpage du tabac à priser: *B. Cyffers.*

GERMANY—

Allgemeines Statistisches Archiv—

Vol. 38, Part 3—Diskriminanzanalyse: *R. K. Bauer.* Statistische und mathematische Aufgabenstellung: *G. Schaub.* Der geringe Sympathiewert des Dienstags: *W. Ludwig.*

Mitteilungsblatt für Mathematische Statistik—

Vol. 6, Part 3—Die Extremwerte bei der laufender Fabrikationskontrolle (Fortsetzung und Schluss): *R. Wartmann.* Stichprobenverfahren dei der Beurteilung von Massengütern, insbesondere von Kohle: *K. Stange.* Die Verhältnisschätzung (ratio estimate) nach der Methode des "Veränderungsfaktos" und der "additiven Veränderungsgrösse": *F. Ronge.* Ein elektronisches Gerät zur Schnell-Ermittlung statistischer Kenngrössen: *W. Masing.*

HOLLAND—

Statistica—

Vol. 8, No. 2—Ordered variables in discontinuous distributions: *S. H. Abdel-Aty.* Statistische analyse van muziek: *J. H. C. Lisman.* Het Examen Statistisch Analyst 1953/1954.

JAPAN—

Faculty of Science, Kyusyu University, Memoirs (Series A)—

June 1954—Empirical functions and interpenetrating sampling procedures: *T. Kitagawa.* Note on the statistical inferences of certain continuous stochastic processes: *T. Seguchi* and *N. Ikeda.*

Hitotsubashi Academy, Annals—

October 1954—On the Soviet concept of national income: *S. Tsuru.* Maximising principle and one method of consistent determination of input coefficients of Leontief system: *I. Yamada.*

Institute of Statistical Mathematics, Annals—

Vol. VI, No. 2—An approach to the density function: *H. Akaike.* On testing statistical hypotheses: *K. Matusita, Y. Suzuki* and *H. Hudimoto.* Decision rule by probability ratio: *K. Matusita.* An estimate of standard deviation of normal population based on the difference between means of two groups divided by sample mean: *M. Siotani.* Statistical research on colloidal graphite I: *I. Higuti.* On the forecasting of prognosis in mediatrics by a quantifying method: *S. Sakino* and *G. Kono.*

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Union of Japanese Scientists and Engineers (*Reports of Statistical Application Research*)—

November 1954—Bounds for second moments of the same range: *S. Moriguti.* On a problem of two populations: *M. Sakaguti.* Power of R-charts: *S. Shimada.* Optimality of orthogonal designs: *S. Moriguti.*

SPAIN—

Trabajos de Estadistica—

Vol. V, Part II—Sur une famille de tests asymptotiques des hypothèses statistiques composées: *J. Neyman.* Superposición de variables aleatorias y sus aplicaciones: *P. Zoroa.* A problem of encounters: *S. Vajda.* La ciencia actuarial: *C. A. Spoerl.* Notas para la enseñanza de algunos conceptos elementales de Estadística en el Bachillerato: *E. Llagunes* and *J. L. Tendero.* Tabla de números aleatorios obtenido de los números de la Lotería Nacional Española: *J. Royo* and *S. Ferrer.*

SWEDEN—

Skandinavisk Aktuarietidskrift—

Parts 1–2 1954—On the multivariate Poisson distribution: *H. Teicher.* On a property of the sequential *t*-test: *P. G. Hoel.* Tests of linear hypotheses concerning binomial experiments: *O. Reiersøl.* On the determination of an optimal sample size: *S. Nordbotten.* A note on the modified *t*-test: *L. Råde.* On regularity conditions for maximum likelihood estimators: *J. Gurland.* Eksamen i Forsikringsvidenskab og Statistik ved Københavns Universitet.

SWITZERLAND—

Schweizerische Zeitschrift für Volkswirtschaft und Statistik—

March 1955—Nochmals Verkehrsgleichung und Quantitätstheorie: *H. G. Bieri.* National income and general productivity in terms of energy: *S. D. Zagoroff.*

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I.—OFFICIAL PUBLICATIONS

United Kingdom. *Air Ministry. Meteorological Office.* Variation of wind with time and distance; by C. S. Durst ... London, H.M.S.O., 1954. 32p. 11″. 4*s.* 6*d.* (Geophys. Mem. 93.)

Board of Trade. Census of distribution and other services, 1950, Vol. III: Wholesale trades ... London, H.M.S.O., 1955. viii, 210p. 12″. 15*s.*

General Register Office. Census 1951 England and Wales: County report ... Anglesey and Caernarvonshire. xliii, 60p. 20*s.* Bedfordshire. xli, 48p. 15*s.* Cambridgeshire and Huntingdonshire. xliv, 72p. 21*s.* Cardiganshire and Pembrokeshire. xliv, 60p. 20*s.* Cornwall. xliii, 62p. 20*s.* Denbighshire and Flintshire. xlv, 62p. 20*s.* Devon. xlvi, 102p. 25*s.* Dorset. xlii, 52p. 17*s.* 6*d.* Gloucestershire. xlvi, 70p. 21*s.* Hampshire. xlviii, 95p. 25*s.* Lincolnshire and Rutland. xlvii, 125p. 27*s.* 6*d.* Norfolk. xlvi, 74p. 21*s.* Oxfordshire. xliv, 47p. 17*s.* 6*d.* Somerset. xlv, 82p. 21*s.* Suffolk. xlix, 82p. 22*s.* 6*d.* Wiltshire. xlii, 58p. 20*s.* London, H.M.S.O., 1954–55. 13″.

Iron and Steel Board. Development of the iron and steel industry, 1953 to 1958. London, H.M.S.O., 1955. iv, 42p. 9½″. 1*s.* 9*d.*

Medical Research Council. Indices of heat stress: a statistical comparison of effective temperature and an index based on sweat loss; F. E. Smith. London, H.M.S.O., 1955. 52p. 9½″. 2*s.* (M.R.C. Mem. 29.)

Ministry of Agriculture and Fisheries. The farm as a business: a handbook of standards and statistics ... London, H.M.S.O., 1954. iii, 107p. 8¼″. 4*s.*

Ministry of Transport and Civil Aviation. Report of the Committee of Inquiry into London Transport. London, H.M.S.O., 1955. viii, 121p. 9½″. 5*s.*

National Savings Committee. Annual report of the National Savings Committee, 1949–1950, in continuation. London, National Savings Committee, 1949–1954. 5 vols. 13″ and 9½″.

Royal Commission on Population. Papers of the Royal Commission on Population, Vol. VI: The trend and pattern of fertility in Great Britain: a report on the family census of 1946: by D. V. Glass and E. Grebenik. Pt. I. Report. Pt. II. Tables. London, H.M.S.O., 1954. 2. vols. 13¼″. 63*s.*

Royal Commission on Scottish Affairs. Minutes of evidence taken before the Royal Commission on Scottish Affairs. First to tenth days, 27th February, 1953 to 18th September, 1953. 9 vols. Index. 8p. 6*d.* Report, 1952–1954. 126p. 4*s.* Cmd. 9212. Volume IV: Memoranda submitted to the Commission by Northern Ireland Departments. 48p. 2*s.* Edinburgh, H.M.S.O., 1953–1954. 9½″.

Royal Commission on the Taxation of Profits and Income. Minutes of evidence taken before the Royal Commission on the Taxation of Profits and Income, eighteenth day to the twenty-first day, June 2nd to July 8th, 1954. London, H.M.S.O., 1954. 4 vols. 13″.

Scotland. General Registry Office. Census 1951 Scotland. Volume III: General volume. Population, age, sex and conjugal condition, birthplace and nationality, gaelic speaking population and housing (Houses, households and household conveniences.) ... Edinburgh, H.M.S.O., 1954. lxx, 135p. 13″. 32*s.* 6*d.*

Census 1951: report on the fifteenth census of Scotland ... Vol. I. Part 33. County of West Lothian. 39p. 9*s.* 6*d.* Part 34. County of Wigtown. 32p. 7*s.* 6*d.* Part 35. County of Zetland. 34p. 8*s.* Edinburgh, H.M.S.O., 1954. 13″.

Treasury. Organisation and Methods Division. Machines and appliances in government offices. Rev. ed. London, H.M.S.O., 1954. 71p. 11″. 7*s.* 6*d.*

Organisation charts and lists of duties. Revised June, 1954. London, H.M.S.O., 1954. 13p. 13″. 1*s.* 6*d.*

The practice of O & M. London, H.M.S.O., 1954. iv, 48p. 9½″. 5*s.*

Canada. *Dominion Bureau of Statistics.* Ninth census of Canada. 1951. Vol. IX: Fisheries. Ottawa, 1954. Various paging. 11″. $3.

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Denmark. *Arbejds-og Socialministeriets.* Indtaegtsgraenser i Dansk lovivning og deres økonomisk betydning: en undersøgelse ved Arbejds-og Socialministeriernes statsvidenskabelige konsulent. Socialt Tidsskrift. (1954), 12, 335–357. 9″. 2 *kr.* (Økonomisk-Statistiske Undersøgelser 19.)

Food and Agriculture Organisation. Report of the special technical meeting on the economic aspects of the rice industry, Rangoon, Burma, 11–18 November, 1954. Rome, F.A.O., 1954. (London, H.M.S.O.) v, 30p. 9″. 2*s.* 6*d.*

Germany. *Statistische Bundesamt.* Der Bestand an Gebäuden in der Bundesrepublik Deutschland nach der Zählung vom 13.9.1950. Stuttgart-Köln, Kohlhammer, 1955. 55p. 11¾″. (Statistik der Bundesrepublik Deutschland Bd. 39.)

Die Nichtlandwirtschaftlichen Arbeitsstätten in der Bundesrepublik Deutschland nach der Zählung vom 13.9.1950. (Textband mit Kartenwerk) Heft 2: Kartenwerk. Stuttgart-Koln, Kohlhammer, 1954. Maps in a folder. 12″. (S.B.D. 47.)

India. *Office of the Registrar General.* Census of India 1951: Literacy and educational standards. New Delhi, 1954. i, 296p. 10¾″. 4*s.* (Census Papr. No. 5.)

Census of India 1951: Volume I. India Part IIC. Economic tables, (rural and urban population). New Delhi, 1954. v, 456p. 11″. 16*s.*

International Labour Office. Systems of social security: United States. Geneva, 1954. xi, 106p. 9½″. 4*s.* 6*d.*

New Zealand. *Census and Statistics Department.* Population census, 1951. Vol. V: Birthplaces and duration of residence of overseas born. 23p. Vol. VI: Maori census. 56p. Appendix B: Life tables, 1950–52 and values of annuities. 31p. Wellington, 1954. 12″.

Customs Department. Statistical classification of exports and imports. Wellington, 1954. 165p. 12″. 10*s.*

Norway. *Statistik Sēntralbyrå.* Nasjon alregnskap, 1938 og 1948–1953. National accounts, 1938 and 1948–1953. Oslo, 1954. 219p. 9½″. (Norges Offisielle Statistikk XI. 185.)

Organisation for European Economic Co-Operation. Industrial censuses in the United States. Paris, O.E.E.C., 1955. 143p. 9½″. 10*s.* (Technical Assistance Mission 77.)

Outline of development of income and employment in Italy in the ten-year period, 1955–64. Paris, O.E.E.C., 1955. 108p. (typewritten). 10½″.

Portugal. *Instituto Nacional de Estatistica.* Inquérito às explorações agrícolas do continente 1953. II: Províncias do Douro Litoral, Beira Alta, Beira Baixa, Beira Litoral e Estremadura. Lisboa, [1954]. x, 453p. 10¼″.

Trabalhos do seminario de econometrica dirigido pelo Prof. H. O. Wold. Lisboa, 1953. 185, 2p. 9″.

Rhodesia. *Central African Statistical Office.* The national income and social accounts of Northern Rhodesia, 1945–1953. Salisbury, 1954. ii, 70p. 13″.

Sweden. *Statistiska Centralbyran.* Befolkningsrorelsen översikt for åren 1941–1950. Stockholm, 1955. xvi, 85p. 9½″. (Sveriges Officiella Statistik.)

Switzerland. *Eidgenossisches Statistisches Amt.* Eidgenossische Volkszählung 1 Dezember 1950. 13. Kanton Schaffhausen. 114p. 17. Cantone Ticino. 154p. Bern, 1954. 2 vols. 11¾″. (Statistische Quellenwerke 262, 265.)

Schweizerische Nationalbank. Das schweizerische Bankwesen im Jahre 1953. Bern, Orell Fussli, 1954. 276p. 9½″.

Union of South Africa. *Bureau of Census and Statistics.* Census of industrial establishments, 1947–48, 1948–49 and 1949–50 ... Pretoria, 1954. v, 229p. 13″. 29*s.*

United Nations. *Educational, Scientific and Cultural Organization.* The university teaching of social sciences: Law; a report prepared by Charles Eisenmann ... Paris, U.N.E.S.C.O., 1954. 133p. 8½″. 6*s.*

United States of America. *National Bureau of Standards.* Tables of the error function and its derivative. Washington, Supt. Documents, 1954. xi, 302p. 10¼″. $3.25. (Appl. Math. Ser. 41.) A reissue of Math. Tabl. 8.

Yugoslavia. *Federal Statistical Office.* Konačni rezultati popisa stanovnistva od 15 marta 1948 godine. Knjiga III. Stanovnšitvo po zanimanju. Beograd, 1954. cxi, 496p. 11½″.

II.—AUTHORS AND MISCELLANEOUS

Adcock, C. J. Factorial analysis for non-mathematicians. Melbourne, University Press, 1954. London, Cambridge University Press. 88p. 8½″. 17*s.* 6*d.*

Adler, Max K. L'étude du marché. Paris, Editions Hommes & Techniques, 1954. 86p. 8″.

Marktonderzoek: een korte cursus voor directeur en verkoopleider. Alphen aan den Rijn, N. Samsom, [1955] 86p. 8¼″.

Moderne Marktforschung: die Voraussetzung fortschrittlicher Unternehmens-Führung. Stuttgart, Forkel, 1955. 160p. 8¼″.

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Allais, Maurice. Les fondements comptables de la macro-économique: Les équations comptables entre quantités glibales et leurs applications. Paris, Presses Universitaires de France, 1954. v, 91p. 10″. *fr*.900.

Bartlett, M. S. An introduction to stochastic processes: with special reference to methods and applications. Cambridge University Press, 1955. xiv, 312p. 8½″. 35*s*.

Problemes de l'analyse spectrale des series temporelles stationnaires. 119–134p. 9½″.

Processus stochastiques ponctuels. *Ann. Inst. Poincaré.* (1954), **14**, 35–60. 10¾″.

Bass, J. Space and time correlations in a turbulent fluid. Part II: Space and time spectrum. Berkeley and Los Angeles, Univ. California Press, 1954. 85–98. 10½″. $25. (Univ. California Publ. in Statistics **2**, 4.)

Biazzi, Alberta. Le teorie economiche dei costi comuni; [by] Alberta Biazzi. Sui fondamenti dell'economica; [by] Felice Vinci. Milano, 1953. 45p. 9¼″. *L*500. (Univ. Studi Milano. Ist. Sci. Econ. Statist. 18.)

Birmingham. *Central Statistical Office.* City of Birmingham. Abstract of statistics No. 3, 1952–1954; edited by Richard Padley and A. B. Neale. Birmingham, 1954. xiii, 139p. 11″. 10*s*. 6*d*.

Bisset, G. B. Financial results on farms in the southern province in 1949/50, 1950/51 and 1951/52. Reading, University, Dept. Agricultural Economics, 1953. 35p. 9¾″. 5*s*. (Farm Management Survey Report 3.)

Bliss, C. I. & Beard, R. L. The growth of the head capsule in individual milkweed bugs. *Ann. Ent. Soc. Amer.* (1954), **47**, 387–392. 9½″

Bliss, C. I. *and others.* Sources of variation in the determination of vitamin D by the line test. *J. Ass. Off. Agric. Chem.* (1954), **37**, 499–508. 10¼″.

Booth, Andrew D. Numerical methods. London, Butterworth, 1955. vii, 195p. 8½″. 35*s*.

Borgatta, Edgar F. & Westoff, Charles F. Social and psychological factors affecting fertility. XXV. The prediction of total fertility. *Milbank Mem. Fd. Quart.* (1954), **32**, 382–419, 1087–1123. 9″.

Brambilla, Francesco. Le equazioni alle differenze finite. Universita di Genova, Istituto per gli Studi di Economia, 1954. 47p. 8¾″.

Brown, A. J. The great inflation, 1939–1951. London, issued under the auspices of the Royal Institute of International Affairs, by Oxford University Press, 1955. xii, [ii], 312p. 8½″. 30*s*.

Brown, B. C. Industrial production in 1935 and 1948. *Bull. Lond. Camb. Econ. Ser.* (1954), Dec., 8p. 9¾″.

Cambridge University. Department of Applied Economics. An application of activity analysis to the theory of the firm; by M. J. Farrell. *Econometrica* (1954), **22**, 291–302. 10″. (Repr. Ser. 84.)

Sample surveys for household income and expenditure information; J. E. G. Utting. *Schweiz. Z. Volks. Statist.* (1954), 90, 8p. (Repr. Ser. 85.)

External impacts of economic developments in U.S.A.; by S. Adler. *Bull. Lond. Camb. Econ. Ser.* (1954), Sept. (*Times Rev. Ind.*). 6p. 9½″.

Carone, G. Der Fremdenverkehr und sein Anteil am Wirtschaftsleben der Region Trentino-Tiroler Etschland. Rovereto, Arti Grafiche R. Manfrini, 1954. 199p. 9½″.

Central Bank of Ceylon. *Department o/ Economic Research.* Report on the sample survey of Ceylon's consumer finances, conducted in May, 1953. Colombo, 1954. ix, 34p. 40 tables. 9½″. 3*s*. 6*d*.

Cheeseman, E. A. & Walby, A. L. The physique of Belfast schoolchildren . . . *Ulster med. j.* (1954), **23**, suppl. 3. 63p. 9½″.

Chernoff, Herman & Lehmann, E. L. The use of maximum likelihood estimates in χ^2 tests for goodness of fit. *Ann. Math. Statist.* (1954), **25**, 579–586. 10″.

Cox, D. R. The design of an experiment in which certain treatment arrangements are inadmissible. *Biometrika* (1954), **41**, 279–295. 11″.

The mean and coefficient of variation of range in small samples from non-normal populations. *Biometrika.* (1954), **41**, 469–481. 11″.

Cox, Peter R. Addendum to Demography: developments during 1949–54. Cambridge, published for the Institute of Actuaries and the Faculty of Actuaries at the University Press, 1955. viii, 64p. 8½″. 5*s*.

Cramér, Harald. On some questions connected with mathematical risk. Berkeley and Los Angeles, Univ. California Press, 1954. 99–124. 10¼″. (Univ. California Publ. in Statistics, **2**, 5.)

Craven, C. A. U. Statistical estimation of the accuracy of assaying. *Trans. Instn. Min. Metal, Lond.* (1953–54), **63**, 551–563. 8½″.

Curwen, M. P. Statistics, medicine and Barts. *St. Bartholomew's Hosp. J.* (1955), **59**, 15–18. 9½″.

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Daniels, H. E. A distribution-free test for regression parameters. *Ann. Maths. Statist.* (1954), **25**, 499–513. 10″.

Saddlepoint approximations in statistics. *Ann. Math. Statist.* (1954), **25**, 631–650. 10″.

Doeblin, Wolfgang. Le cas discontinu des probabilités en chaîne. *Publ. Fac. Sci. Univ. Masaryk.* (1937), **236**, 13p. 8″.

Éléments d'une théorie générale des chaînes constantes simples de Markoff. *C. R. Acad. Sci. Paris* (1937), **205**, 7–10. 10½″.

Étude de l'ensemble de puissances d'une loi de probabilité. *C. R. Acad. Sci. Paris.* (1938), **206**, 718–720. 10½″.

Exposé de la théorie des chaînes simples constantes de Markoff à un nombre fini d'états. *Rev. Math. Union Interbalkanique* (1938), **2**, 29p. 11¼″.

Premiers éléments d'une étude systématique de l'ensemble de puissances d'une loi de probabilité. *C. R. Acad. Sci. Paris.* (1938), **206**, 306–308. 10½″.

Sur deux problèmes de M. Kolmogoroff concernant les chaînes dénombrables. *Bull. Soc. Math. Fr.* (1938), **66**, 11p. 10″.

Sur le cas continu des probabilités en chaîne. *R. C. Accad. Lincei.* (1937), **25**, 170–176. 11¼″.

Sur l'équation de Smoluchowsky. *Prakt. Akad. Athen.* (1937), **12**, 116–119. 10″.

Sur l'équation matricielle $A(t + s) = [A^{(t)} A^{(s)}]$ et ses applications aux probabilités en chaîne. *Bull. Sci. Math.* (1938), **62**, 12p. 10″.

Sur les propriétés asymtotiques des mouvements régis par certains types de chaînes simples. Propositions données par la faculté. Bucuresti, Imprimeria Centrala, 1938, 123p. 10½″. Thèses presentée à la Faculte des Sciences de l'Université de Paris.

Sur les sommes d'un grand nombre de vecteurs aléatoires. *C. R. Acad. Sci. Paris.* (1938), **207**, 511–514. 10½″.

Doeblin, Wolfgang & Fortet, Robert. Sur des chaînes à liaisons complètes. *Bull. Soc. Math. Fr.* (1937), **65**, 17p. 10″.

Edey, Harold C. & Peacock, Alan T. National income and social accounting. London, Hutchinson, 1954. viii, 9–222p. 7½″. 8*s.* 6*d.* (Hutchinson University Library: Economics.)

Fisher, Sir Ronald. The analysis of variance with various binomial transformations. *Biometrics* (1954), **10**, 130–151. 9¼″.

Fortunati, Paolo. Primi risultati di una indagine statistica sull'imposta di famiglia a Bologna. Spoleto, Panetto & Petrelli, 1953. 26p. 9½″.

Gordon, Margaret S. Employment expansion and population growth: the California experience, 1900–1950. Berkeley and Los Angeles, University of California Press, 1954. London, C.U.P. xiii, 192p. 9¼″. 26*s.*

Grundy, P. M. *and others.* Decision between two alternatives: how many experiments. *Biometrics* (1954), **10**, 317–323. 9¼″.

Hammersley, J. M. Storage problems. *Math. Annalen.* (1955), **128**, 475–478. 9″.

Hammersley, J. M. & Morton, K. W. The estimation of location and scale parameters from grouped data. *Biometrika* (1954), **41**, 296–301. 10¾″.

Harris, W. F. Statistics and the accountant. London, Society of Incorporated Accountants, 1954. 38p. 9½″. 10*s.*

Hartley, Sir Harold. Science and industry—the pattern of the future? Southampton University, 1954. 24p. 8½″. (Fawley Foundation Lecture.)

Healy, M. J. R. Statistical techniques for inspection sampling. *Trop. Agriculture, Trin.* (1955), **32**, 10–19. 9¾″.

Herdan, G. Quality control by statistical methods. London, Nelson, 1948. xii, 251p. tabs. diagrs. 8″. 21*s.*

Hoblyn, T. N. *and others.* Some considerations in the design of successive experiments in fruit plantations. *Biometrics* (1954), **10**, 503–515. 9½″.

Hodges, J. L., jr. & Lehmann, E. L. Matching in paired comparisons. *Ann. Maths. Statist* (1954), **25**, 787–791. 10″.

Hyman, Herbert H. *and others.* Interviewing in social research. Chicago, University of Chicago Press, 1954. London, C.U.P. xvi, 415p. 9″. 60*s.*

International Statistical Institute. 28 Session de l'Institut International de Statistique, Rome, 6–12 Septembre, 1953. *Bull. Int. Statist. Inst.* (1953), **34**, 2, 3. 2 vols. 10″.

Ivrea. *Gruppo Tecnico per il Coordinamento Urbanistico del Canavese.* La determinazione dell' area di influenza di Ivrea . . . Ivrea, Olivetti, 1954. 5 vols. 12″. *L*1000 each.

Jeeves, T. A. Identification and estimation of linear manifolds in *n*-dimensions. *Ann. Maths. Statist.* (1954), **25**, 714–723. 10″.

Kendall, M. G. The role of statistics in scientific research. *Virginia J. Sci.* (1954), **5**, 119–130. 9½″.

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Digitized by Arya Samaj Foundation Chennai and eGangotri

Klein, Lawrence R. *editor.* Contributions of survey methods to economics. New York, Columbia University Press, 1954. London, Cumberlege. ix, 269p. 9″. 48*s.*

Klein, Lawrence R. A textbook of econometrics. Evanston, Ill., Row, Peterson & Co., 1953. ix, 355p. 9″.

Koop, J. C. Investigations to ascertain age-specific fertility rates of certain Burman populations and some related methodological problems. Rome, World Population Conference, United Nations Economic and Social Council, 1954. ii, 12p. typewritten. 11″.

A note on the bias of the ration estimate. *Bull. Inst. Int. Statist.* (1951), **33**, II, 141–146. 9½″.

Preliminary report on the labour force sample survey of Rangoon related to the period 20th March to 19th April, 1954. *Burma Labour Gazette* (1954), **7**, 5–6. 13¼″.

A sample count of the number and distribution by the size of industries in Rangoon. *Burma Labour Gazette* (1954), **7**, p. 6. 13¼″.

Kuczynski, Jurgen. Die Geschichte der Lage der Arbeiter in England von 1640 bis in die Gegenwart. Band IV, Teil 1, Teil 2. 1640 bis 1760, 1760 bis 1832. Berlin, Tribune, 1954. 2 vols. 8¼″.

LeCam, Lucien. Note on a theorem of Lionel Weiss. *Ann. Maths. Statist.* (1954), **25**, 791–794. 10″.

Leiblein, Julius. A new method of analyzing extreme-value data. Washington, 1954. 88p. 10½″. (National Advisory Committee for Aeronautics Tech. Note 3053.)

Lent, George E. The ownership of tax-exempt securities, 1913–1953. New York, National Bureau of Economic Research, 1955. 140p. 9″. $1.50. (N.B.E.R. Occ. Pap. 47.)

London. Stock Exchange. Interest and dividends upon securities quoted on the Stock Exchange during the years 1950 to 1954. London, published by the authority of the Council of the Stock Exchange, 1955. 23p. 10″. 2*s.* 6*d.*

London School of Economics. Division of Research Techniques. The correlation between variate values and ranks in samples from a continuous distribution; by Alan Stuart. *Brit. J. Statist. Pysch.* (1954), **7**, 37–44. 9¾″. (Repr. Ser. 31.)

Asymptotic relative efficiences of distribution-free tests of randomness against normal alternatives; Alan Stuart, *J. Amer. Statist. Ass.* (1954), **49**, 147–157. 9¼″. (Repr. Ser. 32.)

An experimental comparison between coders; J. Durbin and A. Stuart. *J. Marketing* (1954), **19**, 54–66. 10″. (Repr. Ser. 33.)

Distribution-free tests in time-series based on the breaking of records; by F. G. Foster and A. Stuart. *J. R. Statist. Soc.* (1954), **B**, **16**, 1–22. 9¾″. (Repr. Ser. 34.)

Distribution-free methods and order properties; by M. G. Kendall and R. M. Sundrum. *Rev. Int. Statist. Inst.* (1953), **3**, 124–134. 11p. 9¾″. (Repr. Ser. 35.)

Callbacks and clustering in sample surveys: an experimental study; by J. Durbin and A. Stuart. *J. R. Statist. Soc.* (1954), **A**, **117**, 387–428. 9¾″. (Repr. Ser. 36.)

Non-response and call-backs in surveys; by J. Durbin. *Bull. Inst. Statist. Inst.* (1953), **34**, 17p. 9½″. (Repr. Ser. 37.)

The projected dictionary of statistical terms; by G (*sic*) Kendall. *Bull. Int. Statist. Inst.* (1953), **34**, 15p. 9½″. (Repr. Ser. 38.)

MacNalty, Sir Arthur Salusbury, *editor.* The civilian health and medical services . . . Volume II: The colonies, the medical services of the Ministry of Pensions, public health in Scotland, public health in Northern Ireland. London, H.M.S.O., 1955. xi, 406p. 9½″. 45*s.* (History of the 2nd World War. U.K. Medical Series.)

Maddan, Martin. Profitable export marketing . . . with an appendix of world information and research sources by Peter Vigart. London, Newman Neame, 1955. 192p. 8¼″. 15*s.*

Maverick, Lewis A. Productivity: a critique of current usage. Carbondale, Ill., printed by the author, 1955. 30p. 9″. 50*c.*

Meade, J. E. The balance of payments. London, issued under the auspices of the Royal Institute of International Affairs, Oxford University Press, 1951. xvi, 432p. 8½″. 30*s.* (The Theory of International Economic Policy I.)

Merrell, Margaret. The family as a unit in public health research. *Hum. Biol.* (1952), **24**, 1–11. 9¼″.

National Bureau of Economic Research. *Conference on Research in Income and Wealth.* Short-term economic forecasting. Studies in income and wealth Vol. 17; Princeton, Princeton University Press, 1955. London, O.U.P. xi, 506p. 9″. $7.50.

National Coal Board. Report of the advisory committee on organisation. London, N.C.B., 1955. [i], iii, 105p. 9½″. 2*s.* 6*d.*

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Digitized by Arya Samaj Foundation Chennai and eGangotri

Netherlands. Central Planning Bureau. Prioriteitsbepaling van overheidsinvesteringen; R. J. P. Van Glinstra Bleeker. *De Economist.* (1954), 817–847. 31p. 9½″. (Repr. Ser. 38.)

The position of economics and economists in the government machine: a comparative critique of the United Kingdom and the Netherlands; by R. L. Marris. *Econ. J.* (1954), **64**, 759–783. 9½″. (Repr. Ser. 39.)

Neuman, A. M. de. Industrial development in Indonesia; Cambridge, Student's Bookshops, 1955. 40p. 8½″.

Neyman, Jerzy & Scott, Elizabeth. Spatial distribution of galaxies: analysis of the theory of fluctuations. *Proc. Nat. Acad. Sci. Wash.* (1954), **40**, 873–881. 10¼″.

Neyman, Jerzy, *and others.* The index of clumpiness of the distribution of images of galaxies. *Astrophys. J.* (1954), Suppl. I, 269–294. 9½″.

North Carolina, University of. Institute of Statistics. Why randomize? B. G. Greenberg. *Biometrics.* (1951), **7**, 309–322. 9″. (Repr. Ser. 17.)

The large-sample power of tests based on permutations of observations; by Wassily Hoeffding. *Ann. Math. Statist.* (1952), **23**, 169–192. 9¾″. (Repr. Ser. 18.)

A lower bound for a probability moment of any absolutely continuous distribution with finite variance; by Sigeiti Moriguti. *Ann. Math. Statist.* (1952), **23**, 286–289. 9¾″. (Repr. Ser. 18a.)

Methodology in the study of physical measurements of school children. Part II. Sexual maturation—determination of immaturity points; by A. Hughes Bryan and B. G. Greenberg. *Hum. Biol.* (1952), **24**, 117–144. 8½″. (Repr. Ser. 19.)

Classification and analysis of partially balanced incomplete block designs with two associate classes; by R. C. Bose and T. Shimamoto. *J. Amer. Statist. Ass.* (1952), **47**, 151–184. 9″. (Repr. Ser. 20.)

Patterson, H. D. The errors of lattice sampling. *J. R. Statist. Soc.* (1954), **B, 16**, 140–149. 9¾″.

Pavlovsky, Giorgio. Appunti bibliografici sui problemi dell'espansione economica e dell'assistenza ai paesi economicamente arretrati. *Riv. Econ. Agrar.* (1954), **9**, 1–10. 9½″.

Pearce, S. C. & Davies, G. E. Studies in the measurement of apple trees. II: The height at which trunk girths should be measured; *Ann. Rep. East Malling Res. Stat.* (1953), 138–140. 9¾″.

Pearce, S. C. & Preston, A. P. Forecasting the time of blossoming in apple trees from temperature records. *Ann. Rep. East Malling Res. Stat.* (1953), 133–137. 9¾″.

Pompilj, Giuseppe & Napolitani, Diego. Piano degli esperimenti ed elaborazione probabilistica dei risultati con particolare riguardo alla sperimentazione in biologia. *La Ricerca Scientificia* (1954), **24**, suppl. A. 206p. 9½″. *L*2000.

Qureshi, D. M. Report on the crop estimation survey on cotton in the Punjab, 1951–52 ... Lahore, 1954. 35p. 10″.

Report of the crop estimation survey on cotton in the Punjab, 1952–53 ... Lahore, 1954. 10p. 10″.

Report on the crop estimation survey on wheat in the Lyallpur District, 1950–51 ... Lahore, 1953. 6p. 10″.

Report on the crop estimation survey on wheat in the Punjab, 1951–52 ... Lahore, 1954. 41p. 10″.

Rand Corporation. A million random digits with 100,000 normal deviates. Glencoe, Ill., The Free Press, 1955. xxv, [ii], 200p. 10½″. $10.

Rexford-Welch, S. C. *editor.* The Royal Air Force medical services. Vol. I. Administration. London, H.M.S.O., 1954. xx, 611p. 9½″. 70*s.* (History of the 2nd World War. U.K. Medical Series.)

Ricardo, David. The works and correspondence of David Ricardo; edited by Piero Sraffa, with the collaboration of M. H. Dodd. C.U.P., for the Royal Economic Society, 1955. x, 424p. 9″. 24*s.* Vol. 10. Bibliographical Miscellany.

Roll, Eric. A history of economic thought. 3rd ed. London, Faber & Faber, 1954. 540p. 8½″. 30*s.*

Roy, Purnendu Mohon. Hierarchical group divisible incomplete block designs with m-associate classes. *Sci. Culture.* (1953), **19**, 210–211. 7½″.

Inversion of incomplete block designs. *Bull. Calcutta Math. Soc.* (1954), **46**, 47–48. 9½″.

A note on the method of inversion of statistical designs. *Sci. Culture.* (1953), **18**, 440–441. 4p. 7½″.

A note on the relation between BIB and PBIB designs. *Sci. Culture* (1953), **19**, 40–41. 5p. 7½″.

A note on the resolvability of balanced incomplete block designs. *Bull. Calcutta Statist. Ass.* (1953), **4**, 130–132. 9¾″.

A note on the unreduced balanced incomplete block designs. *Sankhyā* (1953), **13**, 11–16. 11″.

CC-0. In Public Domain. Gurukul Kangri Collection, Haridwar

Digitized by Arya Samaj Foundation Chennai and eGangotri

On the method of inversion in the construction of partially balanced incomplete block designs from corresponding BIB designs. *Sankhya* (1954), **14**, 39–52. 11″.

Rectangular lattices and orthogonol group divisible designs. Bull. Calcutta Statist. Ass. (1954), **5**, 87–93. 9½″.

Shevky, Eshref & Bell, Wendell. Social area analysis: theory, illustrative application and computational procedures. Stanford, Calif., Stanford University Press, 1955. London, Cumberlege. vi, 70p. 9″. 14*s*. (Stanford Sociological Series I.)

Tagliacarne, Guglielmo. Variazioni territoriali dello stato economico fra il 1938 e il 1952 in Italia e in altri paesi, concentramento o perequazione? *Studi e Monografie della Societa Italiana di Economia Demografia e Statistica N.* 7 (1954). 59p. 9½″. *L*800.

Tamagnini, Eusebio. A propósito do índice cefálico dos portugueses: questoes de metodo I. *Rev. Fac. Sci. Côimbra* (1933), **2**, 23p. 9½″.

A heterogemeidade da variação a análise da variância: questoes de método II. *Rev. Fac. Sci. Côimbra.* (1938), **6**, 19p. 9½″.

Tate, Robert F. Correlation between a discrete and a continuous variable. Point-biserial correlation. *Ann. Maths. Statist.* (1954), **25**, 603–607. 10″.

Taylor, Wallis. Comparative fertility in the local government areas of England and Wales, 1951. *Brit. J. Prev. Soc. Med.* (1954), **8**, 176–177. 9¾″.

Current differential infantile mortality England and Wales. *Brit. J. Prev. Soc. Med.* (1954), **8**, 157–161. 9¾″.

A note on the sex distribution of sibs. *Brit. J. Prev. Soc. Med.* (1954), **8**, 178–179. 9¾″.

Taylor, Wallis & Dauncey, Marjorie. Changing pattern of mortality in England and Wales. II: Maternal mortality. *Brit. J. Prev. Soc. Med.* (1954), **8**, 172–175. 9¾″.

Turner, A. J. Quality in flax ... Lisburn, Co. Antrim, Linen Industry Research Association, 1954. x, 249p. 9¾″. 21*s*.

Uppsala University. Institute of Statistics. University Institute of Statistics Uppsala: selected papers Vols. 2–9. Uppsala, various dates. 9 vols.

Walker, A. M. The asymptotic distribution of serial correlation coefficients for autogressive processes with dependent residuals. *Proc. Camb. Phil. Soc.* (1954), **50**, 60–64. 10″.

Westoff, Charles F. Differential fertility in the United States: 1900 to 1952. *Amer. Sociological Rev.* (1954), **19**, 549–561. 10″.

Williams, E. J. Estimation of components of variability. Melbourne, Commonwealth Scientific Research Organization, 1954. 22p. 9½″. (Tech. Papr. 1.)

Wishart, John. The factorial moments of the distribution of joins between line segments. *Biometrika* (1954), **41**, 555–556. 11″.

Yates, Frank. Análise de una expériencia de rotação. *Bragantia* (1952), **12**, 213–235. 9″.

The analysis of experiments containing different crop rotations. *Biometrics.* (1954), **10**, 324–346. 9¼″.

Zwiedineck-Südenhorst, Otto von. Menschenzahl und Menschenschicksal: Prolegomena zur Theorie eines Gesetzes abnehmender Wirtschaftsfreiheit. *Z. Nationalökonomie* (1954), **14**, 208–235. 9″.

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VOL. 118.] [PART III

Journal of the Royal Statistical Society

SERIES A (GENERAL)

PART III, 1955.

A Statistical Examination of The Megalithic Sites in Britain

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[Read before the Royal Statistical Society, March 23rd, 1955, the President, Lord Piercy, C.B.E., in the Chair]

Introduction

In the past twenty years I have visited some 250 megalithic sites in England and Scotland, and made accurate surveys where there appeared to be anything worthy of survey. The surveys were carefully made plans showing the position of every stone except those obviously loose. Particular attention was paid to the orientation of the plans, the azimuths being determined in nearly every case astronomically by theodolite observations of the sun. This mass of material provides data for a geometrical and statistical study of the sites. The sites examined consist mainly of circles of standing stones, of rows of standing stones, here called alignments, or of a combination of the two. Many of the circles have one or more outliers, i.e. single upright stones outside the ring.

Of the published plans of stone circles, some are lacking in accuracy, and only one or two contain determinations of azimuth and horizon altitudes. Thus, in a study of the possible astronomical significance of stone alignments, etc., they are quite useless. There is also the danger that if published surveys are used the data may be biased and unsuitable for statistical examination. Accordingly in the present paper the material is restricted to sites I have been able to visit, and strict attention has been paid to laying down and adhering to terms of reference in selection. In the analysis presented here, nothing has been excluded which has a bearing on the subject, except one or two sites which I am assured are fakes. A list of all the sites used in this paper, circles and alignments, is given in Table 1, with the latitude and longitude of each.

It is proposed to examine three different things:

(1) The geometry of the "circles".
(2) The possibility that a common unit of length was used.
(3) The possibility that the alignments and the outliers had an astronomical significance.

Each of these presents a different problem in statistical analysis. The data should be adequate, but completely rigid methods of attack are lacking.

The Geometry of the Circles

Of the circles surveyed, some forty seem to be true circles or rather were intended by their erectors to be true circles, two are egg-shaped, and about twelve are circles with part of the circumference flattened in a curious manner. I thought at first that this flattening was due either to accident or to earth movement, but when I surveyed the very large circle near Little Salkeld called *Long Meg and her Daughters*, I saw that here at least the slope of the ground was such that no likely earth movement could have produced the flattening. I accordingly tried to fit the

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TABLE 1

List of Sites Used

H = Hebrides. P = Perth and district.
M = Mull and district. G = Galloway and Lowlands.
A = Argyllshire. L = Lake District and North England.
S = South England. D = Derbyshire and district.

No.	*Locality or Name*	*Latitude*	*Longitude*
H 1/1	Callanish I, Lewis	58° 12′	6° 45′
H 1/2	Callanish II, Lewis	58° 12′	6° 44
H 1/3	Callanish III, Lewis	58° 12′	6° 43′
H 1/10	"Steinacleit", Lewis	58° 24′	6° 27′
H 3/8	"Na Fir Bhreige", N. Uist	57° 38′	7° 13′
H 3/11	"Leacach an Tigh Chloiche"	57° 35′	7° 21′
H 3/17	"Pobull Fhinn", N. Uist	57° 34′	7° 17′
H 3/18	"Sornach Coir Fhinn", N. Uist	57° 33′	7° 18′
H 4/2	Gramisdale, Benbecula	57° 28′	7° 18′
H 7/9	Kirkibost, Skye	57° 11′	6° 4′
M 1/4	Dervaig A, Mull	56° 36′	6° 11′
M 1/5	Dervaig B, Mull	56° 35′	6° 10′
M 2/14	Lochbuie, Mull	56° 21′	5° 51′
A 1/2	Loch Nell, Lorne	56° 24′	5° 24′
A 1/4	Loch Seil, Lorne	56° 20′	5° 33′
A 2/6	Carnasserie, Kilmartin	56° 9′	5° 29′
A 2/8	Temple Wood, Kilmartin	56° 7′	5° 30′
A 2/12	Duncracaig, Kilmartin	56° 7′	5° 29′
A 2/14	Kilmichael Glassary, A	56° 5′	5° 27′
A 2/21	Kilmichael Glassary, B	56° 5′	5° 28′
A 3/4	Tayvallich, Knapdale	56° 1′	5° 39′
A 4/4	Ballochroy, Kintyre	55° 43′	5° 37′
A 5/8	Scalasaig, Colonsay	56° 4′	6° 12′
A 6/4	Knockrome, Jura	55° 52′	5° 55′
A 8/6	Machrie Moor, Arran	55° 32′	5° 19′
A 9/2	Etterick Bay, Bute	55° 51′	5° 7′
A 9/7	Kilchattan, Bute	55° 45′	5° 3′
A 11/1	Duntreath, Strathblane	56° 0′	4° 21′
G 3/7	Torhouse, Wigtown	54° 53′	4° 31′
G 3/12	Drumtrodden, Port William	54° 46′	4° 33′
G 4/1	Carsphairn	55° 13′	4° 18′
G 4/9	Loch Mannoch, Galloway	54° 55′	4° 5′
G 4/12	Cambret Moor (W), Creetown	54° 54′	4° 19′
G 4/14	Cambret Moor (E), Creetown	54° 53′	4° 18′
G 6/1	"Twelve Apostles", Dumfries	55° 6′	3° 39′
G 7/2	"Seven Brethren", Dumfriesshire	55° 8′	3° 13′
G 7/4	"Loupin Stanes", Eskdale	55° 15′	3° 10′
G 7/5	"Girdlestanes", Eskdale	55° 14′	3° 10′
G 8/2	"Ninestone Rig", Castleton	55° 16′	2° 45′
G 8/9	"Eleven Shearers", Hownam	55° 28′	2° 20′
P 1/1	Dalchirla, Muthill	56° 19′	3° 54′
P 1/2	Dunblane	56° 11′	4° 0′
L 1/1	"Castle Rigg", Keswick	54° 36′	3° 6′
L 1/2	Setmurthy, Cumberland	54° 40′	3° 17′
L 1/3	"Sunkenkirk", Millom	54° 17′	3° 16′
L 1/4	Boot, Cumberland	54° 25′	3° 16′
L 1/7	"Long Meg and her Daughters"	54° 44′	2° 40′
L 1/9	Glassonby, Cumberland	54° 45′	2° 40′
L 2/2	Tarn Moor, Helton	54° 35′	2° 48′
L 2/13	Oddendale, Shap	54° 31′	2° 38′
L 2/14	Orton, Westmorland	54° 2′	2° 33′
L 3/1	Felkington, Northumberland	55° 41′	2° 7′
L 6/1	"Devils Arrows", Boroughbridge	54° 6′	2° 23′
D 1/2	"Wet Withers", Derbyshire	55° 18′	1° 40′
S 2/1	"Grey Wethers", Dartmoor	50° 38′	3° 55′
S 2/2	Merrivale, Dartmoor	50° 33′	4° 3′
S 2/3	Brisworthy, Dartmoor	50° 28′	4° 1′
S 2/4	Ringmoor Down, Dartmoor	50° 28′	4° 2′
S 2/5	Trowlesworthy, Dartmoor	50° 27′	4° 0′
S 2/7	Lee Moor, Dartmoor	50° 31′	4° 1′
S 3/1	Stanton Drew, Somerset	51° 22′	2° 34′
S 4/1	Winterbourne Abbas, Dorset	50° 43′	2° 33′
S 4/2	Kingston Russell, Dorset	50° 42′	2° 35′
S 6/1	Rollright, Oxfordshire	51° 38′	1° 34′

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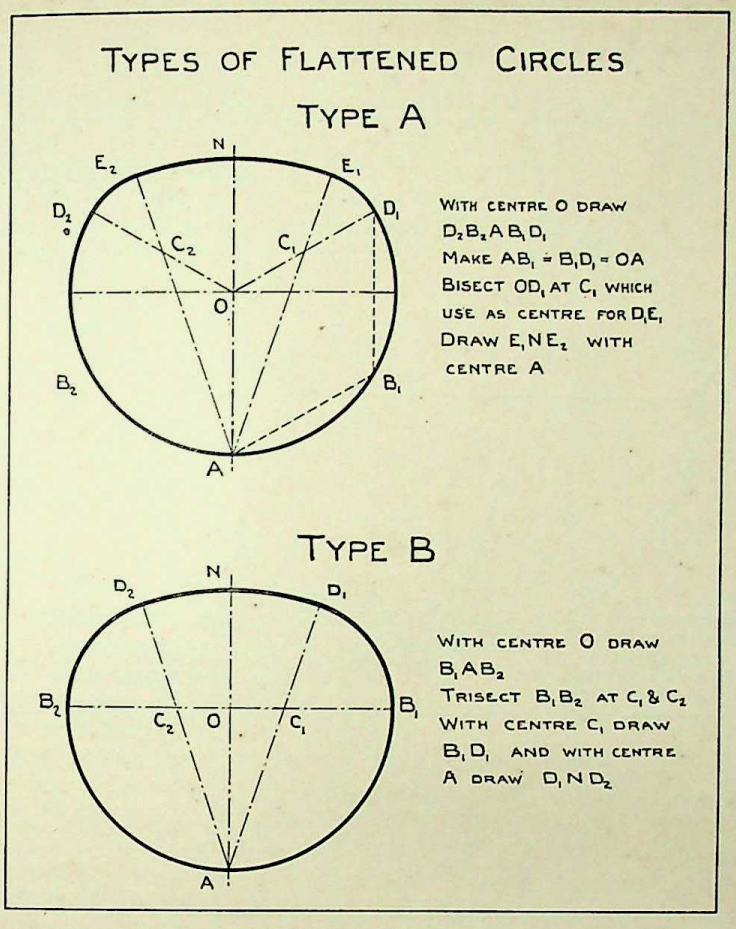


FIG. 1

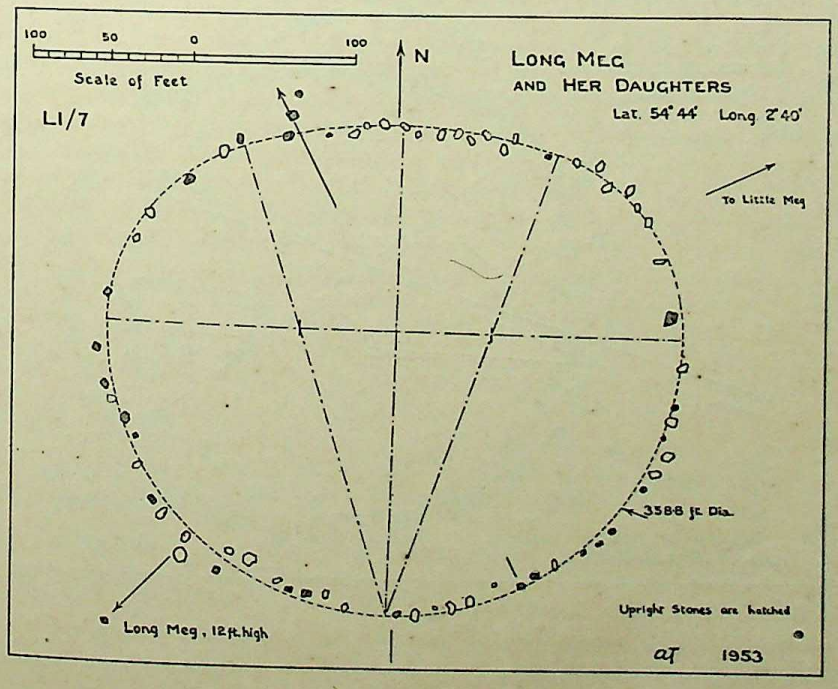


FIG. 2

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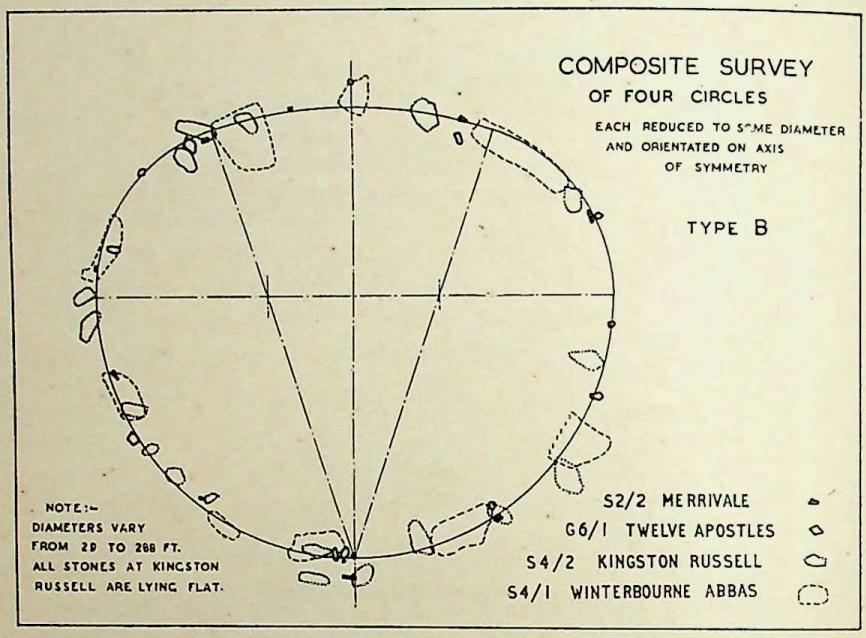


FIG. 3

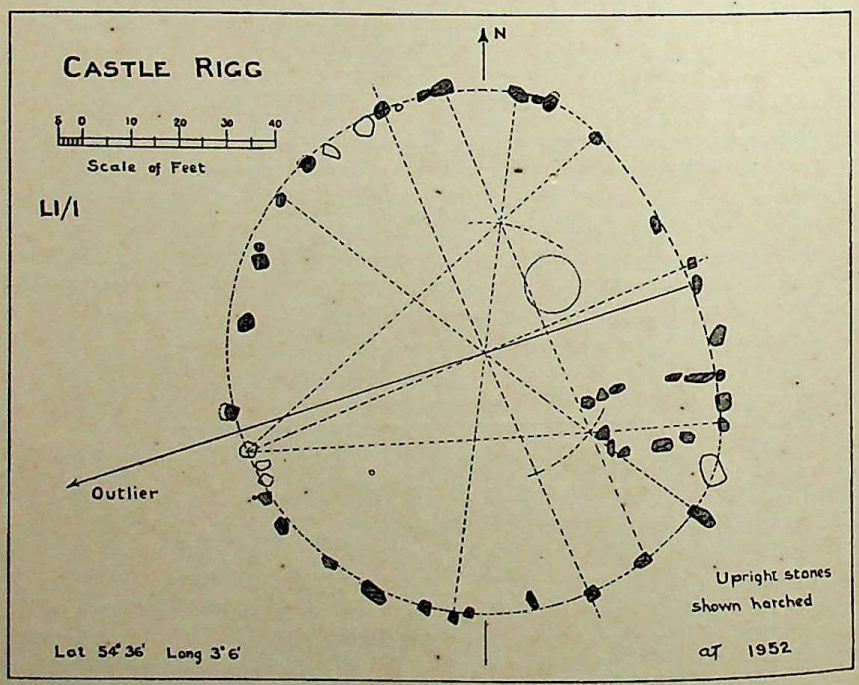


FIG. 4

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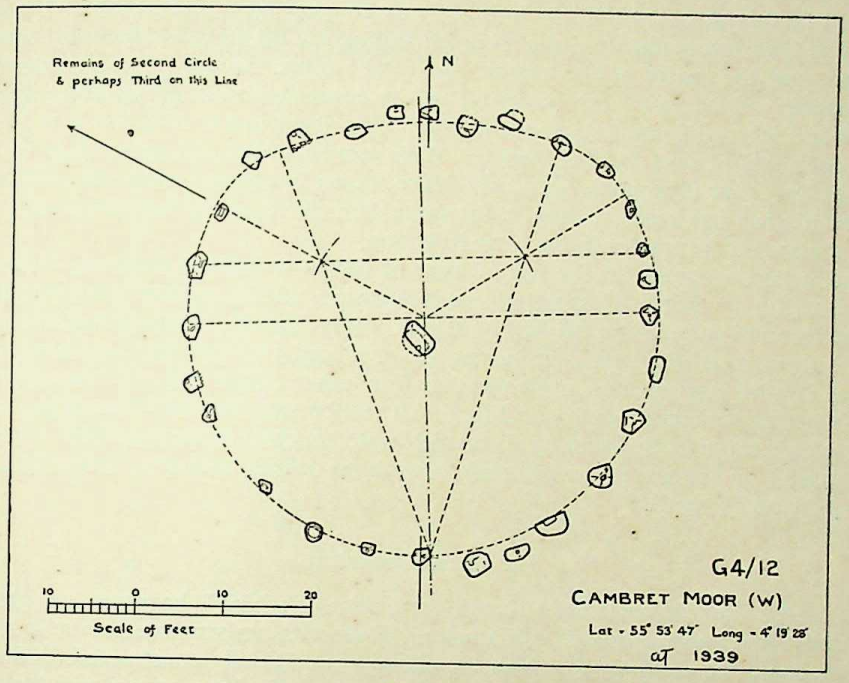


FIG. 5

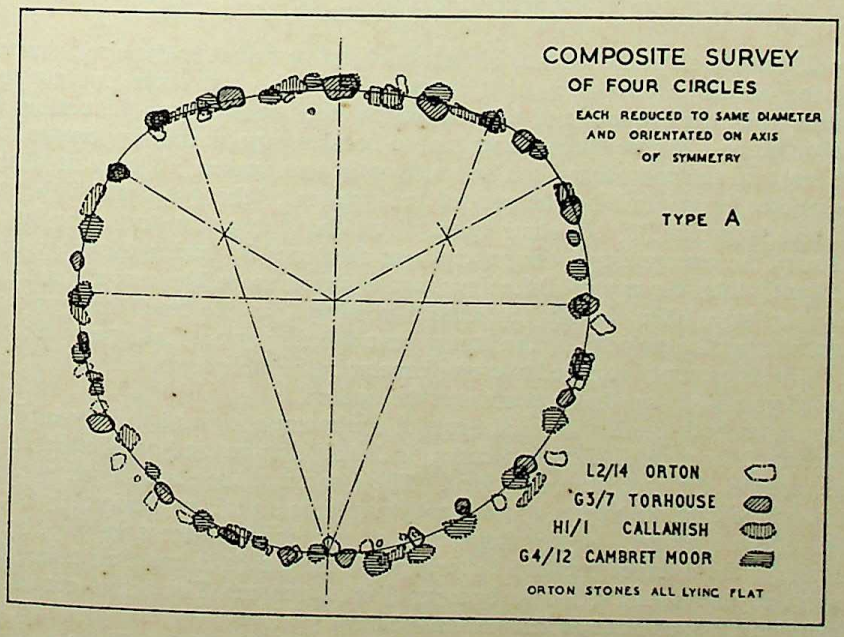


FIG. 6

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construction Type B in Fig. 1. It appears from Fig. 2 that the curve passes through the stones as closely as can be expected of any simple geometrical figure. As a start, I assumed a radius R of 180 ft. and further assumed that the axis of symmetry lay north and south. The distance of each stone was then measured from the assumed outline by taking the estimated centre of each upright stone, and the centre of the nearest end of the fallen stones. A least squares solution was then possible, which gave corrections (*a*) to the co-ordinates of the assumed centre, (*b*) to the radius R and (*c*) to the orientation of the axis. The new value of R is 179·4 ft., and the axis of symmetry need only be rotated 1·2 degrees. This geometrical construction, Type B, was found to apply to at least four other sites, all of which are shown in the composite diagram, Fig. 3. In this figure each circle has been reduced to the same diameter, and all superimposed on the same centre with the axes of symmetry in the same direction.

The construction assumed for the second type of flattened circle is shown in Type A, Fig. 1. It will be seen (Fig. 4) that at Castle Rigg, near Keswick, all the necessary construction points, changes of radius and 60° arcs are marked by stones. It is difficult to believe that this could occur by chance, but no method of rigid proof can be produced to show that this construction was actually used by the erectors. In my collection four other circles fall into this group (e.g. see Fig. 5) and these are brought together in Fig. 6. It will be seen that both constructions A and B are such that they could easily be made in the field with no other equipment than a piece of rope and a few stakes. In the surveys so far made there is no definite sign of a flattening intermediate between Type A and Type B.

The Circle Diameters

Tables 2 and 3 contain particulars for all the circles of which I have made a proper survey and for which I can approximate to a diameter. Even with an accurate survey it is sometimes difficult to estimate the diameter to which the circle was originally constructed. Often many of the stones have fallen and it must be remembered that trees may have grown over the site at some time and caused distortion. Unfortunately, there is no sure method of knowing if the circle has been tampered with in recent times by well-meaning persons. Thus, for the two circles at *The Grey Wethers* on Dartmoor, Worth (1953) gives a survey made last century by Lukis, which shows many of the stones fallen, whereas all are now upright. I have used this small copy of Lukis's survey to identify, as far as possible, the stones upright in 1879 and these only were taken into consideration for the estimates of diameter in this paper, but some doubt exists about the south circle.

In nearly all cases the method used to obtain an objective value for the circle diameter was as follows: Having drawn on the survey what appeared to be the best circle (or flattened circle of the appropriate type), the azimuth and distance of the stone centre from the outline were noted for each upright stone. Where fallen stones had to be used a point midway between the stone's centre (as it lies) and the end nearest the assumed outline was taken. The most likely diameter was then calculated by minimizing the sum of the squares of the distances of the stones from the outline (see Appendix II). In some cases where the stones were more or less uniformly distributed round the circumference the process was shortened by taking the mean displacement in each quadrant; then the mean of the four was assumed to be the correction to the radius. Where all stones have fallen the above methods possibly bias the result one way or another, depending on whether the majority of the stones have fallen in or out; otherwise the error should be random. The uncertainty attached to each diameter in the tables is an *estimate* of the standard deviation based principally on the scatter about the outline.

The results from both the English and Scottish circles are shown pictorially in Fig. 7. Each circle is represented by a small Gaussian curve or distribution centred on the diameter. Where two or more overlap, the ordinates are added. There seems to be some advantage in this form of diagram when the data are scanty. It evidently produces a peak approximately over the mean of the values within a group. In the simple case of two equal adjacent values, there will be a single maximum if the distance between the centres of the curves is less than twice the standard deviation, and two peaks with a hollow between if it is greater. The actual curves used had a standard deviation twice as large as that in the tables.

There are four main peaks in the figure near 22, 44, 55 and 66 ft. If the radii were made multiples of a man's height, or a man's span (c.f. the fathom) or something like the Roman double

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TABLE 2

Circle Diameters—England

D = Diameter, m = multiplier, z = | D—5·435 m |
Type A and B—see Fig. 1; Type C—Circle

Site	*Assumed Type*	*D (feet)*	*m*	5·435 *m*	*z*	*Remarks*
S 2/4	C	11·9±0·3	2	10·87	1·03	Circle
S 2/7	C	16·0±0·3	3	16·30	0·30	closing
S 2/5	C	22·3±0·3	4	21·74	0·56	avenue
L 2/13	C	24·0±0·5	4	21·74	2·26	Concentric
S 4/1	B	29·7±0·3	5	27·17	2·53	Fair
L 3/1	C	31·5±0·3	6	32·61	1·11	Good
S 2/4	C	41·2±0·3	8	43·48	2·28	—
L 1/9	C	47·7±0·5	9	48·91	1·21	Poor
L 1/4	C	51·7±0·5	10	54·35	2·65	,,
L 1/4	C	53·3±0·5	10	54·35	1·05	,,
L 1/4	C	54·9±0·5	10	54·35	0·55	,,
L 1/4	C	66·3±0·5	12	65·22	1·08	,,
S 2/2	B	67·4±0·3	12	65·22	2·18	? Type
S 2/8	C	81·4±0·3	15	81·52	0·12	Good
L 2/13	C	86·0±0·5	16	86·96	0·96	Concentric
S 4/2	B	91·1±1·0	17	92·39	1·29	All fallen
L 1/3	C	93·7±0·3	17	92·39	1·31	Good
D 1/2	C	96·9±0·5	18	97·83	0·93	With bank
S 3/1	C	103·1±0·5	19	103·26	0·16	Fair
S 6/1	C	103·6±0·3	19	103·26	0·34	Good
S 2/1	C	104·5±0·3	19	103·26	1·24	Re-erected
L 1/1	A	107·0±0·3	20	108·70	1·70	Mostly erect
S 2/1	C	108·5±0·3	20	108·70	0·20	Re-erected
L 1/2	C	113·4±0·5	21	114·13	0·73	Poor
L 2/14	A	145·9±1·0	27	146·74	0·84	All fallen
L 1/7	B	358·8±0·5	66	358·71	0·09	Many fallen
S 3/1	C	370·5±1·0	68	369·58	0·92	,, ,,

TABLE 3

Circle Diameters—Scotland

D = Diameter, m = multiplier, z = | D—5·435 m |
Type A & B—see Fig. 1; Type C—Circle

Site	*Assumed Type*	*D (feet)*	*m*	5·435 *m*	*z*	*Remarks*
A 2/8	C	11·2±0·3	2	10·87	0·33	Good
A 1/2	C	14·0±0·3	3	16·30	2·30	Poor
G 4/9	C	20·9±0·3	4	21·74	0·84	Good
H 7/9	C	21·0±1·0	4	21·74	0·74	Part buried
A 2/12	C	21·0±0·5	4	21·74	0·74	Poor
M 2/14	C	21·8±0·3	4	21·74	0·06	Good
G 8/2	C	23·2±0·5	4	21·74	1·46	Poor
H 1/1	C	24·0±0·5	4	21·74	2·26	Half circle
G 7/4	A	38·7±0·5	7	38·05	0·65	Fair
H 1/1	A	43·3±0·3	8	43·48	0·18	Good
M 2/14	C	44·1±0·3	8	43·48	0·62	,,
A 2/8	C	44·2±0·3	8	43·48	0·72	,,
G 4/12	A	54·5±0·3	10	54·35	0·15	Fair
A 8/6	C	54·9±0·5	10	54·35	0·55	,,
H 1/3	C	55·0±0·5	10	54·35	0·65	Poor
A 1/2	C	65·1±0·3	12	65·22	0·12	,,
G 7/2	A	66·4±0·3	12	65·22	1·18	Fair
G 3/7	A	69·3±0·3	13	70·65	1·35	Good
H 1/2	C	70·0±0·3	13	70·65	0·65	Poor
G 4/14	C	82·1±0·3	15	81·53	0·57	Good
H 4/2	C	87·4±0·3	16	86·96	0·44	Fair
H 3/17		124·0±1·0	23	125·01	1·01	Circle arc
G 7/5	C	130·9±1·0	24	130·44	0·46	Part circle
H 3/18	C	139·0±1·0	26	141·31	2·31	,, ,,
G 6/1	B	288·4±1·0	53	288·06	0·34	? Type

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pace, the diameters would be multiples of two of these units, or about 11 ft. In the first place, the Scottish and English values were examined separately to find what value near to 5½ ft. best suited the *diameters*. It appears that a value of 5·435 ft. closely represents both sets. The diameters (D) and the necessary multipliers (m) are shown in Tables 2 and 3. The value of $\Sigma D \div \Sigma m$ is found to be 5·436 for Scotland and 5·434 for England. We now propose to test the significance of the English value when applied to Scottish diameters. It is found that twenty of the twenty-five values fall in the ranges 5·434 ($m \pm \frac{1}{4}$). As the probability with a random distribution is ½, the deviation from the expected value is about three times the standard error. Reversing the procedure, and testing the Scottish value on the English diameters gives about the same result. The latter calculation was, however, sensitive to the exact value of the unit used and it would seem much better to use the method given by Broadbent (1955). To apply either Broadbent's tables or the binomial distribution method to our problem is perhaps not logically defensible, since the unit being tested is derived from the data itself whereas strictly speaking it ought to come from some outside source. An attempt to get over this difficulty has been made by dividing the data into two groups and taking the value obtained in the one group as the value to be tested by the second.

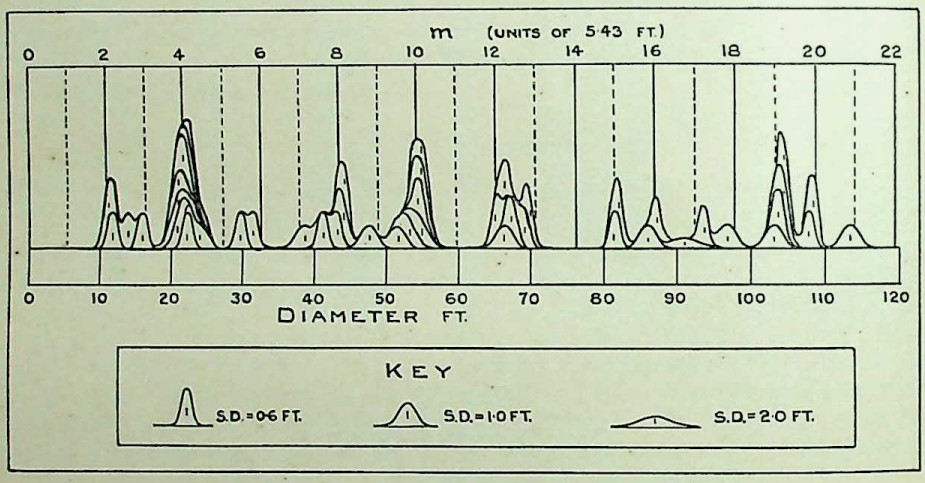


FIG. 7

Broadbent finds the variance of the difference between the quantity and the nearest multiple of the assumed unit. The tables he quotes then give the probability level, allowing for the fact that we may have associated any particular value with the wrong multiple. Thus writing 2δ for the assumed unit of length (5·435 ft. in our case) we put $ns^2 = \Sigma z^2$ where

$$z = | D - 2m\delta |$$

We then enter the table with s^2/δ^2 and deduce the probability level. The results for various groupings of the diameters are given in Table 4. Fig. 7 suggests that these favourable values

TABLE 4

Probability of Obtaining the Observed Groupings if the Circle Diameters had been Random

Group	$s^2 = \frac{\Sigma (D - 2m\delta)^2}{n}$	$\left(\frac{s}{\delta}\right)^2$	*Probability Level*
All English circles . . .	1·744	0·236	<0·05
All Scottish circles . . .	1·097	0·149	0·001
All with D < 80 ft. . . .	1·732	0·235	<0·05
All with D > 80 ft. . . .	0·954	0·129	0·001

D = Diameter; 2δ = assumed unit = 5·435 ft.; m = multiplier.

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are obtained because there are a number of the smaller circles with diameters near to 22, 44 and 55 ft. and these were perhaps simply popular sizes. But when the last two groups in Table 4 are compared it appears that a very much better agreement is found for the twenty circles larger than 80 ft. than for those smaller. Thus it appears that a unit of about 5·43 ft., or a sub-multiple thereof, was in common use throughout Britain.

It should be mentioned that the value of the unit (i.e. $\Sigma D/\Sigma m$) is slightly larger for the circles under 80 ft. than for the others. This may be an indication that some of the circles were measured to the inside of the stones instead of the centre, but the evidence does not show that this was universal.

The Astronomical Significance of the Megalithic Remains

There is little doubt that certain of these sites contain a pointer to the rising or setting points of the sun at the solstices and equinoxes, and indeed this is borne out by the results to be given presently. There is a strong suspicion that others contain a similar indication for the sun at May Day, Candlemas, Martinmas and Lammas—days which are midway in time between the equinox and the solstice. Some of the evidence for the eight dates is contained in a recent paper (Thom, 1954). But as it might be argued that the evidence for the four intermediate dates (declination $\pm 16°$) is not conclusive, it is proposed to ignore the possibility that they were used. The present investigation is mainly a study of the evidence for the hypothesis that many of the sites contain pointers to the rising or setting points of the first magnitude stars. All pointers found which do not indicate the solstice or equinox are grouped together and examined as indicators for these stars.

The argument is frequently put forward that there are so many bright stars that one or another is certain to rise or set on any chosen point on the horizon. The weakness of this contention becomes apparent when it is realized that in our latitudes only about a dozen first magnitude stars are so placed that, on a level horizon, they do in fact rise or set. The others are always either above or below the horizon. It will also be apparent that, within reason, it is not very important what magnitude we decide to take as the lower limit, as the use of a larger number will increase the number of "successes" to be expected as well as the actual number of successes. So I have, arbitrarily, used only first magnitude stars, i.e. all stars brighter than mag. 1·5.

The Pointers

For present purposes a direction in the horizontal plane (i.e. an azimuth) can be specified by a pointing consisting of:

(*a*) An outlier to a circle.
(*b*) The line joining two stones.
(*c*) The line joining the centres of two circles or sites.
(*d*) Two vertical slabs in line, thus — —.
(*e*) A row of three or more stones.
(*f*) A prominent natural feature, e.g. a mountain top indicated by (*b*), (*c*), (*d*) or (*e*) or more simply by the long edges of a single vertical slab.

To restrict the material to a manageable amount and to make the terms of reference more definite, it is proposed here to deal only with (*a*), (*d*) and (*e*).

In listing examples according to the above definitions it is still difficult to know where to draw the line, e.g. should a group of stones like *The Whispering Knights* at the Rollright Circle (S6/1) be treated as an outlier? I decided to do so because of the "hole stone" in the circle periphery on the line from the centre to *The Whispering Knights*, and if *The Whispering Knights* why not also include *Little Meg* as an outlier to the circle at *Long Meg and her Daughters*? Other borderline cases have been excluded as being more properly classified under (*c*) above. None of the Dartmoor double rows is included.

A histogram of the azimuthal distribution shows very little of interest except a group of pointers near the true north direction. It is proposed to accept these as intentional and to ignore them.

Further progress can only be made by converting the azimuths to declinations. For this we use the expression:

$$\sin \delta = \sin h \sin \lambda + \cos h \cos \lambda \cos A \quad . \quad . \quad . \quad . \quad (1)$$

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where h is the observed angular altitude of the hill or sea horizon corrected for astronomical refraction, A the azimuth, δ the declination and λ the latitude. Each point on the horizon corresponds to a definite value of the declination and so may perhaps be associated with a particular heavenly body, e.g. a star, since a star's declination changes only slightly in a century.

TABLE 5

Outliers

Site	*Azimuth*	*Altitude*	*Declination*	*Site*	*Azimuth*	*Altitude*	*Declination*
H 1/1	See refs		+ 0·3°	G 4/1	100·4°	3·1°	− 3·5°
H 1/1	8 and 10		+ 7·0°	G 4/12	289·5°	0	+10·7°
H 1/1	9·9°	1·6°	+32·5°	G 7/2	228·0°	1·0°	−21·9°
H 1/10	88·5°	0·7°	+ 1·0°	G 7/2	236·1°	0·7°	−18·4°
H 3/17	288·9°	0·7°	+10·2°	G 7/2	251·7°	0·2°	−10·6°
H 3/18	313·1°	0·6°	+21·6°	G 7/2	46·6°	1·3°	+23·9°
H 3/18	318·5°	0·7°	+24·0°	G 7/2	334·3°	0·6°	+31·2°
M 2/14	223·6°	0·4°	−23·7°	L 1/1	252·1°	3·2°	− 7·8°
M 2/14	237·0°	2·1°	−16·0°	L 1/7	223·4°	1·1°	−24·2°
M 2/14	123·4°	6·8°	−12·0°	L 1/7	65·1°	3·4°	+16·7°
A 1/2	147·5°	6·6°	−21·8°	L 1/7	333·6°	0·3°	+31·1°
A 2/8	141·2°	1·8°	−24·4°	L 2/2	201·3°	3·6°	−29·4°
A 2/8	135·0°	3·0°	−20·8°	L 2/13	252·0°	1·7°	− 9·2°
A 2/8	115·7°	7·1°	− 8·2°	L 2/13	12·5°	0·7°	+34·7°
A 3/4	32·8°	1·9°	+29·5°	S 3/1	94·9°	1·5°	− 2·1°
A 8/6	282·2°	0·9°	+ 7·3°	S 3/1	72·3°	0·7°	+11·2°
A 9/2	77·5°	1·4°	+ 7·8°	S 3/1	63·5°	0·8°	+16·5°
G 3/7	89·6°	1·0°	+ 0·5°	S 6/1	94·9°	−0·2°	− 3·7°
G 3/7	81·2°	1·5°	+ 6·0°	S 6/1	28·7°	−0·1°	+32·0°

TABLE 6

Alignments

Site	*Azimuth*	*Altitude*	*Declination*	*Site*	*Azimuth*	*Altitude*	*Declination*
H 3/8	288·9°	2·3°	+11·7°	A 2/21	166·1°	1·9°	−31·2°
M 1/4	341·1°	0·0°	+30·8°	A 4/4	225·0°	0·0°	−24·0°
M 1/5	154·0°	1·6°	−28·4°		44·2°	6·6°	+29·6°
	334·0°	0·8°	+30·3°	A 5/8	222·7°	0·7°	−24·0°
A 1/4	146·8°	6·9°	−21·3°	A 6/4	73·7°	1·9°	+10·4°
	326·1°	5·3°	+32·1°	A 9/7	310·9°	0·7°	+21·9°
A 2/6	168·7°	2·4°	−30·9°		134·5°	2·5°	−21·3°
A 2/8	203·5°	0·3°	−30·9°	A 11/1	56·7°	7·2°	+24·0°
	23·5°	2·2°	+32·5°	G 2/4	240·5°	2·4°	−14·8°
A 2/8	149·6°	2·0°	−27·1°	G 3/12	43·3°	0·4°	+24·8°
	329·6°	5·8°	+34·0°	G 8/9	94·7°	4·1°	+ 0·5°
A 2/12	151·9°	1·1°	−28·8°	P 1/1	237·3°	5·6°	−12·7°
	331·9°	3·1°	+32·2°		57·3°	1·8°	+18·7°
A 2/12	140·7°	2·3°	−23·7°	P 1/2	195·0°	1·5°	−31·5°
	320·7°	3·1°	+28·2°		13·5°	0·5°	+32·7°
A 2/14	138·2°	3·4°	−21·7°	L 6/1	150·9°	0·4°	−30·9°
	318·2°	1·9°	+26·0°		330·9°	0·7°	+31·0°

All the available data for pointers giving declinations between −35° and + 35° (the limits for latitude 55° with a flat horizon) are contained in Tables 5 and 6, where there are particulars for thirty-eight outliers and twenty-two alignments. The distribution in declination of all pointers is shown in Fig. 8, where each observed declination is shown, as for the circle diameters, by a small Gaussian curve placed with its centre over the observed declination. The width of the curve used corresponds to a standard deviation of about ± 0·25° which is roughly the uncertainty given by an outlier 100 ft. distant.

A difficulty arises with the alignments, in that we do not know which way to look. For ten of these the direction pointed has, for one reason or another, been assumed; for the other twelve it seemed best to use both directions, adjusted slightly to any natural feature which seemed to be indicated. In the two-directional alignments one pointing will be spurious* and allowance will

* That is unless we assume that the erectors were ingenious enough to make use of both directions by taking advantage of varying hill altitudes.

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have to be made for this in the subsequent analysis. An alternative procedure was considered, namely, to assume that we should always look along the line from the lowest stone to the highest. This procedure would tend to make Fig. 8 still more convincing, but it seems more logical at this stage to sight from both ends. Those pointings which at the site seemed more impressive have been shaded, and it appears that nearly all the shaded areas lie in one or other of the concentrations. On the figure the declinations of all first magnitude stars in the range are shown plotted for dates between 2400 and 1800 B.C. (Neugebauer, 1912). The declination of the sun, calculated from Newcomb's constants (Newcomb, 1895), at important days of the year has also been shown. The reason for expecting the sun's declination from the equinoctial sites to differ from zero is given fully in a recent paper (Thom, 1954). It depends on the fact that the erectors had no astronomical instruments as we know them, but could only define the equinox as that date on which the sun set over a mark which had been established as marking the setting point exactly half a year before; half a year later it would be back at the same mark. On these dates the sun's declination (2000 B.C.) would be not zero but, owing to the ellipticity of the earth's orbit, $+ 0{\cdot}5°$.

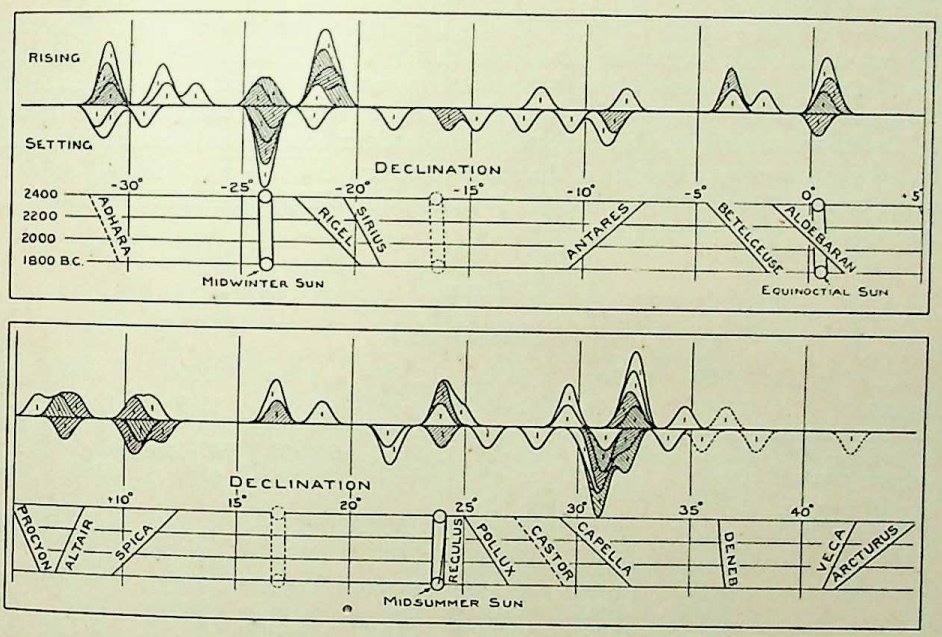


FIG. 8

It will be seen that many of the observed values agree with the sun or star declinations for a date around 2000 B.C. The agreement is more impressive when it is recalled that at least twelve of the values are, as explained above, spurious.

To examine more closely the significance of the agreements the following procedure was adopted: Eight periods, of 200 years, were each treated in the same way. The range of declination of the star in the 200 years was widened, arbitrarily, by $0{\cdot}2°$ at each end. For the sun the widening was $0{\cdot}5°$ since there is uncertainty as to which edge of the sun the builders observed, and the semi-diameter is about $0{\cdot}3°$. It is proposed to call these widened intervals "pockets" and the number of pointers falling into the pockets the "catch". The catch by the sun at the solstices and equinoxes is definitely significant (see later). Accordingly these pockets and all observed pointers caught in them were removed before the data was further examined.

A difficulty now appears. If the distribution of pointers is random in azimuth it will not be so in declination. A greater concentration will be obtained in the higher part of the declination range. In fact declination is not linear with azimuth and therefore logically we should convert the declination pockets into azimuth pockets. Each pocket in the declination range was multiplied by the factor $dA/d\delta$ as calculated from (1) for zero horizon altitude and for a mean latitude of 55°.

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Evidently the integral of this expression over the mean declination range (which for $\lambda = 55°$ is $\delta = \pm 35°$) is 180°. We have in fact made the analysis at least approximately linear in azimuth. It may seem strange that we first reduced the azimuths to declinations and now seek to revert to azimuth; but we had to convert to declination first in order to determine the catch accurately. If all the sites were in a flat plain and all in the same latitude this procedure would, of course, be unnecessary. When the analysis is made entirely on a declination basis the results are very little different, indicating that we are making a sufficiently close approximation by using the method described. The labour involved in any rigid method would be prohibitive, necessitating the measurement of horizon altitudes over a range of azimuth at every site.

Sun catch.—The sun, in latitude 55° at the equinoxes and solstices, provides round the horizon six pockets, with a total width of about 12·9°; so $p_s = 12{\cdot}9/360 = 0{\cdot}036$. The number of pointers falling into the sun pockets from outliers and alignments is twelve or thirteen (depending on the date) out of a total of seventy-two. On any method of reduction this is significant, so it is proposed to proceed as mentioned above and remove the sun pocket and the sun catch before analysing the star catch.

Star catch—outliers.—Let us illustrate first by the simple case of the outliers, since these are essentially one-directional. From the total azimuth range of 360° remove the sun pockets leaving 347·1° (see Table 7). The total width of the pockets covered by the first magnitude stars, allowing for overlap, was carefully computed for each 200 years' interval and expressed as a fraction p of 347·1°. The actual catch minus the expected (on a random distribution) enables the value of the deviation to be expressed as a fraction of the standard error $\sqrt{N p(1-p)}$. It will be seen (Table 8) that the mid-dates 2100 and 1900 B.C. stand out clearly with a high significance level; all the other dates show a value below significance.

TABLE 7

Open Pockets

Mid-date B.C.	2700	2500	2300	2100	1900	1700	1500	1300
S = Sun pocket	12·9°	12·9°	12·9°	12·9°	12·9°	12·9°	12·9°	12·9°
A = Total arc to be used = (360° − S)	347·1°	347·1°	347·1°	347·1°	347·1°	347·1°	347·1°	347·1°
a = Total star pocket	39·5°	47·5°	50·8°	48·7°	48·3°	47·4°	51·8°	48·9°
a_0 = Total pocket arc facing pocket arc	2·5°	2·2°	3·7°	0·0°	5·5°	2·3°	0·0°	0·0°
$a - a_0$	37·0°	45·3°	47·1°	48·7°	42·8°	45·1°	51·8°	48·9°
$p_1 = (a - a_0)/A$	0·107°	0·131°	0·136°	0·140°	0·123°	0·130°	0·149°	0·141°
$p_2 = a_0/A$	0·007°	0·006°	0·011°	0·0°	0·016°	0·007°	0·0°	0·0°
$p = p_1 + p_2$	0·114°	0·137°	0·147°	0·140°	0·139°	0·137°	0·149°	0·141°

TABLE 8

Outliers Only

Mid-date B.C.	2700	2500	2300	2100	1900	1700	1500	1300
Total number	38	38	38	38	38	38	38	38
Sun catch	7	7	7	7	8	8	7	7
N = difference	31	31	31	31	30	30	31	31
Star catch	4	2	7	14	10	4	6	4
Np = expected catch	3·5	4·2	4·6	4·3	4·2	4·1	4·6	4·4
Deviation	0·5	2·2	2·4	9·7	5·8	0·1	1·4	0·4
$\sigma = \sqrt{\{Np(1-p)\}}$	1·77	1·91	1·97	1·93	1·90	1·88	1·98	1·94
Deviation/σ	0·28	1·15	1·22	5·02	3·05	0·05	0·71	0·21

Star catch—alignments.—The alignments need more careful handling. For all the sites (or for any selected group of sites) let n_1 = number of alignments for which the direction of sighting is assumed known, plus the number of pointers given by outliers, n_2 = number of two-directional alignments, then $N = n_1 + 2n_2$ = number of pointers.

We must introduce a factor to allow for the fact that a two-directional alignment may pick up an open pocket at each end. Thus, let p_2 = proportion of catching pockets or parts of pockets

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which fall on the horizon opposite other catching pockets expressed as a fraction of 347·1°, and let p_1 = proportion of pockets not opposite another pocket, then it appears* that the expected catch is given by

$$c_e = (n_1 + 2n_2)(p_1 + p_2) = Np \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and the variance of the catch is

$$\sigma^2 = n_1 p(1 - p) + 2n_2\{p_1(1 - 2p_1) + 2p_2(1 - p_2) - 4p_1 p_2\}. \quad . \quad . \quad (3)$$

It is impossible to calculate p_2 accurately. The value given (Table 7) is for latitude 55° and assumes a horizontal horizon all round. It is relatively so small that any error here would seem to be negligible.

The results for the alignments alone are shown in Table 9. It will be seen that the significance again attains a maximum for the mid-date 2100 B.C., but that all other dates fall below significance.

TABLE 9

Alignments Only

Mid-date B.C.	2700	2500	2300	2100	1900	1700	1500	1300
Total number	34	34	34	34	34	34	34	34
Sun catch	5	5	5	5	5	5	5	5
$N = n_1 + 2n_2$	29	29	29	29	29	29	29	29
$2n_2$	22	22	22	22	22	22	22	22
n_1	7	7	7	7	7	7	7	7
Star catch	4	4	4	8	4	2	3	2
Np = expected catch	3·3	4·0	4·3	4·1	4·0	4·0	4·3	4·1
Deviation	0·7	0	0·3	3·9	0	2·0	1·3	2·1
σ (see Eq. 3)	1·67	1·77	1·84	1·75	1·84	1·78	1·79	1·7
Deviation/σ	0·4	0	0·2	2·2	0	1·1	0·7	1·2

Outliers and Alignments

Since strong doubts have been expressed about the astronomical explanation of alignments, etc., it is safer to assume that there is no *a priori* reason for testing the theory. Hence, as in the case of the diameters, I have divided the data into two geographical groups:

(*a*) All North-West of the River Clyde (Table 10) and
(*b*) All South-East of the River Clyde (Table 11).

TABLE 10

Outliers and Alignments N.W. of Clyde

Mid-date B.C.	2700	2500	2300	2100	1900	1700	1500	1300
Total number	46	46	46	46	46	46	46	46
Sun catch	8	8	8	8	9	9	8	8
$2n_2$	20	20	20	20	20	20	20	20
n_1	18	18	18	18	17	17	18	18
Star catch	5	4	8	12	9	4	7	4
Deviation/σ	0·4	0·6	1·1	3·3	1·8	0·6	0·6	0·7

TABLE 11

Outliers and Alignments S.E. of Clyde

Mid-date B.C.	2700	2500	2300	2100	1900	1700	1500	1300
Total number	26	26	26	26	26	26	26	26
Sun catch	4	4	4	4	4	4	4	4
$2n_2$	2	2	2	2	2	2	2	2
n_1	20	20	20	20	20	20	20	20
Star catch	3	2	3	10	5	2	2	2
Deviation/σ	0·3	0·6	0·1	4·3	1·2	0·6	0·8	0·7

* The author is indebted to Mr. J. M. Hammersley for the necessary analysis.

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The results show the same characteristics as before. It might be argued from the figures that there is a tendency for the northern group to be a little later than the southern.

Taking all pointers together (Table 12) the value of deviation/standard error is 5·2 for the date 2100 B.C., indicating a very high significance.

TABLE 12

All Outliers and Alignments

Mid-date B.C.	2700	2500	2300	2100	1900	1700	1500	1300
Total number	72	72	72	72	72	72	72	72
Sun catch	12	12	12	12	13	13	12	12
$2n_2$	22	22	22	22	22	22	22	22
n_1	38	38	38	38	37	37	38	38
Star catch	8	6	11	22	14	6	9	6
Deviation/σ	0·5	0·8	0·8	5·2	2·2	0·9	0·0	0·8

Effect of Extending the Magnitude Range

An examination of Fig. 8 shows that there is a group of pointers over the second magnitude star Adhara. Although perhaps we should not change the terms of reference after starting the analysis, it is interesting to see what happens when we extend the range from magnitude 1·5 to magnitude 1·6. Only two more stars now come in, namely Adhara and Castor. Repeating the whole calculation exactly as before we find the results shown in Table 13. The significance for the dates 2100 and 1900 B.C. has increased still further, but, as before, no significance emerges for the other dates.

TABLE 13

All Outliers and Alignments (with Adhara and Castor)

Mid-date B.C.	2700	2500	2300	2100	1900	1700	1500	1300
Total number	72	72	72	72	72	72	72	72
Sun catch	12	12	12	12	13	13	12	12
Star catch	9	6	14	28	19	9	11	11
$p_1 = (a - a_0)/A$	0·148	0·170	0·173	0·158	0·157	0·158	0·179	0·173
$p_2 = a_0/A$	0·007	0·006	0·011	0·017	0·016	0·016	0·005	0·0
Deviation/σ	0·1	1·6	1·1	6·1	3·1	0·5	0·0	0·2

Other possible Explanations of the Azimuths

To be logical we must examine all imaginable hypotheses. Since significant grouping does not take place unless the azimuths are converted into declinations, we need only consider astronomical explanations, but there may be others than that already examined. For declinations in the range $\pm$ 24° one can always explain any declination by associating it with a particular day in the solar year. For declinations $\pm$ 28° other writers have pointed out that this is the maximum possible lunar declination, and in Fig. 8 we do seem to have one or two pointers near to these values. Finally, the group of pointers near $\pm$ 32° might have been erected to show the most northerly and southerly setting points of the planet Venus. But none of these alternative explanations gives as convincing a picture of the whole range as that provided by the sun and first magnitude stars.

Future Work

If the geometrical constructions suggested in Fig. 1 were not actually employed by the builders, then one would expect that the estimates of diameters obtained in Tables 2 and 3 by the use of these constructions would be at variance with those obtained from the true circles; but they appear to show significant agreement. Were the number larger more reliance could be placed on this method of assessing the probability that these patterns were actually used. This indicates the importance of obtaining many more accurate surveys.

The validity of the astronomical hypothesis having been established, the terms of reference might be widened to include more pointers by accepting the definitions (*b*), (*c*) and (*f*). This increases the data to such an extent that the country can be examined district by district. At the

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same time, it would be an advantage to use a date interval smaller than 200 years in order to get a more precise value for the mean date in an area.

It will be appreciated that in building up the data, much ultimately depends on the investigator and therefore the validity of his conclusions depends upon his judgment and honesty. Were it possible to publish all the observed data, with surveys where necessary, the whole case could be better established. Until a method of publishing in considerable detail can be found, all that can be done is to say that the stated terms of reference have been adhered to, and that nothing which can affect the conclusions has been suppressed.

Conclusion

The study of a single megalithic site can only provide a limited amount of information, more especially as it is unlikely that there is such a thing to-day as a completely undisturbed example. We must examine many, and this immediately makes it necessary to introduce statistical methods of analysis. There are a number of problems to be solved and some of these are presented in such a form that they seem to call for special treatment and methods.

From an examination of three of these problems it appears that many of the circles follow certain geometrical designs; that a universal unit of length was used in setting these out on the ground and that many of the constructions carry indications of astronomical uses beyond those associated with the sun. Existing statistical theory allows us to be reasonably certain about the last two statements, but there seems to exist no method of attaching a value to the probability that the geometrical designs suggested were intended.

References

1. Worth, R. H. (1953), *Dartmoor*. Plymouth: Latimer Trend.
2. Keiller, A. (1934), *Megalithic Monuments of North-East Scotland*. Brit. Assoc. Paper.
3. Kendrick, T. D. & Hawkes, C. F. C. (1932), *Archaeology in England and Wales* 1914–1931. London: Methuen.
4. Stevens, F. (1938), *Stonehenge, To-day and Yesterday*. Official Guide. London: H.M.S.O.
5. Royal Commission on the Ancient and Historical Monuments and Constructions of Scotland, (1914): *Galloway, Kirkcudbright*.
6. North, F. J. (1940), *Antiquity*, **14**, 377–394.
7. Piggott, S. & C. N. (1939), *Antiquity*, **8**, 138–158.
8. Thom, A. (1954), *Brit. Astro. Assoc. Journ.*, **64**, 396–404.
9. Broadbent, S. R. (1955), *Biometrika*, **42** (in press).
10. Somerville, B. (1912) *Brit. Astro. Assoc. Jour.*, **23**, 83–96
11. Newcomb, S. (1895), *The Fundamental Constants of Astronomy*. Supplement to the *American Ephemeris and Nautical Almanack* for 1897. Washington.
12. Neugebauer, P. V. (1912), *Tafeln zur Astronomischen Chronologie*, **1**. Leipzig: J. C. Hinrichs'sche Buchhandlung.

Appendix I

Other Information on Diameters

All other workers' measurements of diameters, known to me at the time of writing, are contained in Table 14. Analysis by Broadbent's method, using the unit (5·435 ft.) derived from my own measurements gives a probability level between 0·01 and 0·001. It thus appears that these values lend strong support to the hypothesis of a universal unit of measurement.

Combining *all* the data an interesting point arises. Putting, as before,

$$z = \mid D - 5{\cdot}435\, m \mid$$

z ranges from 0 to 2·7175.

Dividing this range into four equal parts, we find the numbers in each to be: 39, 29, 6 and 12. Does the high value (namely 12) in the upper range indicate that some of the circle diameters were made multiples of half a unit?

The very high proportion of even values of m in all three Tables 2, 3 and 14 will also be noticed. In fact, out of a total of eighty-six circles fifty-six have an even value of m, a very unlikely proportion in a random distribution.

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TABLE 14

Diameters from Other Sources

Site	Diameter	5·435 *m*	*m*	Ref.	Notes
Stonehenge, Blue Stone	78·0	76·1	14	3	—
,, Trilithons	103·0	103·3	19	4	Outside 108, inside 98.
,, Z holes	130·0	130·4	24	3	—
,, Y holes	180·0	179·4	33	3	—
,, Aubrey holes	288·0	288·1	53	3	—
Egryn Abbey	111·0	108·7	20	3	—
,, ,,	159·0	157·6	29	3	—
Image Wood	11·3	10·9	2	2	—
Cairnwell	28·0	27·2	5	2	—
Binghill	33·6	32·6	6	2	—
Raes of Clune	54·2	54·4	10	2	—
Aquorthies	72·0	70·7	13	2	—
Auld Kirk o' Tough	102·7	103·3	19	2	—
Fernworthy	65·5	65·2	12	1	One foot added to reduce to stone centres.
Langstone Moor	58·0	59·8	11	1	
Down Ridge	82·0	81·5	15	1	
Buttern Hill	82·0	81·5	15	1	
Scorhill	89·0	87·0	16	1	
Sherberton	97·0	97·8	18	1	
Cordon Whitemoor	67·0	65·2	12	1	
Crick Barrow	92·0	92·4	17	6	—
Rempstone	76·0?	76·1	14	7	Scaled.
Overton	130·0	130·4	24	3	—
,,	65·0	65·2	12	3	—
,,	46·0	43·5	8		Scaled from small plan.
,,	32·0	32·6	6		
,,	12·0	10·9	2		
Drannandow	89·0	87·0	16	5	Scaled.
Claughreid	34·0	32·6	6	5	Scaled, Type B.
Clava Circles	53·0	54·4	10		Communicated.
,, ,,	22·0	21·7	4		
,, ,,	108·0	108·7	20		
Bar Brook	43·0	43·5	8		Communicated by K. Shaw.
Ashopton	50·0	48·9	9		

APPENDIX II

Least Squares Solution for "Circle" Diameters

Let ACB Fig. 9 be the assumed outline the size being specified by $R = OB$

let Δ = distance of a stone S outside the ring
$\rho = OC$
β = angle between OC and the normal to the outline

let R increase by a small amount r then ρ increases by $\rho r/R$ and so Δ decreases by $(\rho r \cos \beta)/R$.

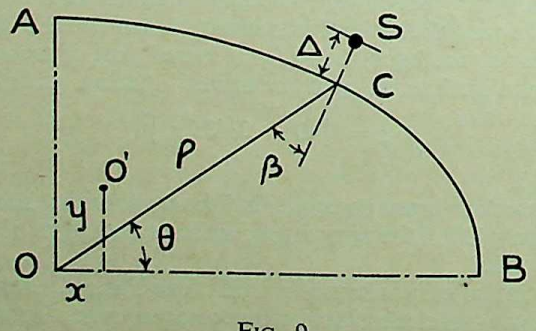


FIG. 9

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Now let the assumed centre O move to x, y and the whole assumed outline OAB rotate through φ then Δ becomes approximately

$$\Delta - (\rho r \cos \beta)/R - x \cos (\theta + \beta) - y \sin (\theta + \beta) - \varphi\rho \sin \beta$$

Equating this to zero gives the necessary relation which can be used for the least squares solution to determine r, φ, x and y. For all the flattened circles except L 1/7 the process was shortened by assuming φ to be zero.

Discussion on Professor Thom's Paper

Professor M. G. Kendall: I move the vote of thanks to Professor Thom with great pleasure. We always give a special welcome to the application of statistical methods to a new field and Professor Thom has provided us with a paper which is not only of great intrinsic interest but raises some fresh problems for the theoretical statistician. One must admire the immense amount of field work which lies behind the paper as well as the moderate and careful way in which the conclusions are stated.

Of the three hypotheses which Professor Thom propounds, the first, as he says, does not seem amenable to a probabilistic treatment but his diagrams seem to me very convincing. His second hypothesis also is very plausible. One would suppose that the unit of length, if there was one, would be in terms of paces rather than heights. One can easily suppose that distances were paced out but if the individuals who constructed these circles were laid end-to-end in a long line one would, to misquote Dorothy Parker, be rather surprised. But if the measurement was done by pacing, the error of a given length would depend on two factors, the number of paces and the deviation from the average of the individual who was making the paces. The quantum hypothesis under test would then be that the variance of an observed length was of the form $an + b$, where n is the number of paces, a is a component representing the error variance of the individual and b is a component representing the variance between individuals. I am not sure whether this is in fact the test which Professor Thom has applied.

I approach the third hypothesis with some prejudice. We are asked to suppose that the peoples who erected these circles had common shapes of construction and a common unit of measurement; but that when it came to alignment they chose the rising of any star as long as it was a bright one. I suppose that such a thing is possible but for me (whose ignorance, I may say in passing, is literally both monumental and astronomical) the prior probability of the hypothesis is lowered. Secondly, it appears that the azimuths are more or less irregularly distributed but the declinations, to which they are simply related by equation (1), are not, Thirdly, Professor Thom uses two arguments which strike me as dubious. The first, on p. 283, is that "it is not very important what magnitude we decide to take as the lower limit, as the use of a larger number will increase the number of 'successes' to be expected as well as the actual number of successes." It seems to me that if one took enough stars one would get a perfect catch, which would prove nothing at all. Again, on p. 285, Professor Thom says "the agreement is more impressive when it is recalled that at least twelve values are spurious". But may this not be begging the question? We do not know that the spurious values are the ones not recorded among the catch.

This catching of stars bears a strong resemblance to one of my favourite forms of skittles, the detection of periodicities in time-series. I therefore constructed from tables of random numbers a set of random azimuths, matching them against the values of h and λ given by Professor Thom, and calculating the declinations. On this basis I get, analogously to Professor Thom's Table 13 (all outliers and alignments, with Adhara and Castor)

Mid-date B.C.	2700	2500	2300	2100	1900	1700	1500	1300
Sun Catch . . .	2	2	2	2	2	2	3	3
Star Catch . . .	5	9	10	9	15	13	13	16

I am far from sure, even with Professor Thom's assistance, that I have done exactly the same thing as he did (apart from the azimuth values) and the experiment would bear repetition. But so far as it goes, it confirms his findings. My values are more or less uniform, whereas his show a peak at 2100 B.C. It would seem that there really is something to be explained here. Whether the orientation by star rising is the correct one is more arguable. Even the maximum catch, sun and stars together, account for only about half the total orientations. Nor are the brightest stars (and Sirius in particular) caught the most frequently. I hope Professor Thom will forgive me if I say that I still have some doubts; but I nevertheless wish to congratulate him on a very stimulating paper which opens up many new lines of thought both in archaeology and statistics.

Mr. Hammersley (in seconding the vote of thanks): I am very glad to have this opportunity of paying tribute to Professor Thom's work. What impresses me most about his paper is the

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breadth of scholarship involved and the wide range of talents necessary to execute the work. Clearly with archaeological work of this character, it is not enough to be a mere archaeologist: one must also be a local historian, a surveyor, an astronomer, an engineer, a statistician, a yachtsman, and a hiker all rolled into one. In these days, when we are apt to pay too much lip-service to narrow specialization and routine research by battalions of doctors of philosophy, it is pleasant to recollect that savants are not yet an extinct species and that those who prospect the no-man's-land between two or more branches of science are very often the real instigators of progress. Not only do such people raise new problems; but they raise them in refreshingly unorthodox ways, which cause us to re-examine in a fresh and critical light the existing foundations of the orthodox structure.

There are two features of Professor Thom's data which are quite obvious and yet worth stressing. In the first place none of his data is replicable; and in the second place they are man-made. Those who work in physical or biological sciences usually have the opportunity of testing a hypothesis by collecting a completely fresh set of data and seeing whether or not it obeys the hypothesis. When they do this, they are testing how well the hypothesis fulfils the essential role it is designed to fulfil, namely that of forecasting data in general as opposed to describing data collected in a single experiment. This is not possible here; there may perhaps be a few undiscovered megalithic sites in the country, but there will certainly not be enough to provide an independent test of Professor Thom's conclusions. Since there is thus no question of forecasting future data, let us examine the character of Professor Thom's hypotheses. They relate, on the one hand, to the dates of construction of these Druid circles, and, on the other hand, to the methods of constructing them. This brings me to the question of the data being man-made. Man is an inveterate pattern-maker; and what Professor Thom is doing in assigning a geometry or a unit of length to these circles is choosing a pattern which seems to him aesthetically satisfying, just as his predecessors forty centuries back chose a pattern aesthetically satisfying to them. I am here using the word "aesthetically" in a suitably wide sense; and one should not overlook the fact that its use must then be wide enough to encompass the two *different* senses employed by modern and ancient man respectively. In the present context, I suspect that modern man employs it in some sense related to Occam's razor: he wants a relatively simple construction, which despite its simplicity nevertheless portrays the main features of the megalithic site. In putting forward some alternative hypothesis, he ought therefore to take account of some measure of the simplicity of the alternative. The issue appears essentially epistemological and one which, despite its importance and wide occurrence, has not been treated much in previous statistical theory. I was puzzled by this issue when treating a somewhat similar though much easier problem (the molecular weight of insulin) at a meeting of the Society four years ago (*J.R. Statist. Soc.* B, **12** (1950) 192–240); but I have not since then been able to contribute towards solving it. I hope however that Professor Thom's paper will encourage others to study the question.

Finally I should like to call attention to the magnificent way in which Professor Thom has condensed some twenty years' work into a paper which is as short as it is lucid. This is an object lesson to all of us, and I have much pleasure in congratulating Professor Thom and seconding the vote of thanks.

Mr. S. R. Broadbent: I should like to say a few words on the statistical problems raised by the common unit of length for the circle diameters. First the question of estimation. Professor Thom has calculated $\Sigma D/\Sigma m$; there are actually better estimators, which give in this case almost the same numerical result. The least squares estimator (which is the maximum likelihood estimator in the case of normal error) is $\Sigma mD/\Sigma m^2$; the estimator which minimizes the criterion s^2/δ^2 is $\Sigma D^2/\Sigma mD$. Both these give on these data the unit 5·434 ft. The reason all three estimations agree so closely is that the main work of estimation is completed when we guess the m corresponding to each D. Unfortunately the three estimators are equally sensitive to the choice of m.

There are logical difficulties raised in the testing of the reality of this common unit. Perhaps I should describe the test briefly. On the hypothesis that the unit of length tested is not in fact obeyed by the data (for example if the distribution of circle diameters were unimodal) it is possible to show that $z = | D - 2m\delta |$ is distributed approximately rectangularly between 0 and δ. Then $s^2/\delta^2 = \Sigma z^2/n\delta^2$ is distributed approximately normally with mean $\frac{1}{3}$ and variance $4/45\,n$. In answer to Professor Kendall's question, it is the alternative or rectangular hypothesis which is tested.

I am not convinced that the separation into English and Scottish circles provides independent sets of data. Once it is decided that the unit is about $5\frac{1}{2}$ ft., the estimates from Tables 2 and 3 are certain to agree closely, and s^2/δ^2 for each is sure to be low. I would therefore regard Table 4, which purports to give the probabilities of the observed groupings, as a *prima facie* significance test only.

The test described in Appendix I, on other measurements of diameters, is, however, a strong

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argument for the common unit of length, as long as these data did not influence the initial choice of $5\frac{1}{2}$ ft. My remarks in fact concern Professor Thom's method, but not his conclusion.

My reasons for being sceptical about Table 4 are as follows. The 52 diameters could be used to test various proposed units of length, from tens of feet to a single foot. For each unit the criterion s^2/δ^2 could be calculated. Its value, graphed against 2δ, the unit tested, would be a continuous oscillating curve. For any 2δ given from an outside source the curve has the expected value $\frac{1}{3}$ and a known standard deviation on the rectangular hypothesis, and so the significance of its value can be tested. If it is small we accept the hypothesis of grouping. But no matter what the real distribution of diameters, the curve will fall below any significance level in some parts of its range, and about these units of length the data will appear to be grouped.

Some sampling experiments are at present being done at the National Physical Laboratory to find where the minima of such curves actually occur. For example, we have taken two samples of 50 observations each, from a uniform distribution between 0 and 1. Any grouping that appears is purely fortuitous. But when testing units of length down to 0·24, both samples admitted units significant at the 5 per cent. level, testing units down to 0·16, both admitted units significant at the 1 per cent. level. This means that if we are free to choose our unit of length after inspecting the data, conventional significance levels have little use. When the National Physical Laboratory calculations are complete we shall have some grounds for such *a priori* testing.

A similar point arises in an elementary way with Professor Thom's (properly guarded) remark that for 56 out of 86 diameters, m is even. Sampling from a binomial population with $p = \frac{1}{2}$ we should obtain this number of successes or more once in 400 trials. Do we therefore reject $p = \frac{1}{2}$ at this level? The point is that this is one of many hypotheses which we might have chosen to test. It is rather like being asked to give prices for the 3.30 race when you know which horse won the race. In such circumstances I think the statistician should hedge about his statements on significance levels with a great deal of caution.

Professor GORDON CHILDE: While archaeologists greatly appreciate the immense amount of work, learning and technical skill which Professor Thom has put into his paper, many of them, I must confess, when faced with mathematical symbols which they do not understand have aroused in them severe emotions which are somewhat unbalanced; some of us think that sigmas and symbols of that kind are "words of power" and any result from their use must have a very high degree of truth. Others are liable to feel that they are deadly weapons which are being used against them to put over a "fast one", and it is only fair to state that this is the attitude which archaeologists are likely to display at the start.

I think also an archaeologist should emphasize the condition of the monuments. Most of the monuments are in a rather dilapidated condition, many of the stones are fallen and some are known to have been tampered with. In the Castle Rigg circle, for instance, there is a rectangular structure which the Prehistoric Society three years ago decided was the foundation of a mediaeval cow-house and not an original part of the circle. At the time of its construction the circle was liable to considerable disturbance. Most of the stones are a very irregular shape, very few of them are squared or even quarried. In most cases I think the builders picked up suitable stones lying about. At Stonehenge the sarsen are dressed, but the stones of most circles are very irregular, and, even when they are standing, it is not at all easy to decide what the centre of the stone is or what it was intended to be.

It is important to remember when considering the question of azimuths and declinations that the landscapes in which the monuments are situated were probably very different at the time they were erected. A great deal of forest has been destroyed since Roman times, some before.

Bearing these limitations in mind let me turn to the results which Professor Thom has laid before us. We archaeologists can admit perfectly freely that prehistoric men were capable of laying out circles with complete accuracy. Stonehenge I and Stonehenge II are certainly strung out from a centre. In some circles one can work out the methods by which the circumference has been sub-divided. Traces of the peg holes for the subsidiary constructions have been observed both in Holland and in this country. These are the sort of operations that have been documented by archaeologists employing the latest excavation techniques.

Whether the diameters so carefully measured by Professor Thom provide statistically valid data for standard measures is beyond my competence to discuss. But if they do what are the inferences which we must draw, if any? I would suggest that we are not dealing here with any conventional standardized unit, it bears no relation to the well-known ancient conventional units which have been worked out by Petrie and others. Professor Thom has not mentioned the Aubrey circle, the figure for which works at 65·22 in. I do not know that we need infer from such figures the existence of a conventional unit. It is only an average obtained from a number of measurements which have diverged more or less from it, and I do suggest that it is the average of the *actual* fathom and not necessarily a conventional fathom. In Egypt they had a conventional fathom

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which was four times the cubit. In this country we have obviously not that fathom, but what we have would work out pretty well judging by the known stature of the people of the period.

Turning to the astronomical values, here again I speak with extreme hesitancy and, in fact, would prefer to say nothing at all except to point out that the dates to which Professor Thom referred are different from those which archaeologists have reached by other methods. It is true that we have no real evidence of the dates of the great majority of the stone circles, but we have good evidence for our dates of Stonehenge I and Stonehenge II. Stonehenge I, which contained no stone whatever, is dated for us by radio-carbon methods at 1850 B.C., which fits in very nicely with the archeological evidence from the encircling ditch. Stonehenge II cannot be dated by the radio-carbon method but from archaeological data, particularly from the type of axe recently discovered curved upon the uprights, the date is somewhere between 1600 B.C. and 1500 B.C. The present tendency of archaeological thought in this country would be very much against putting any stone circle earlier than Stonehenge I.

We think that the stone circles in Scotland are likely to be later than those in England and we would not put any English circle earlier than 1850 B.C. Archaeological data on the whole fit in with the radio-carbon dates.

I should perhaps question the hypothesis that these circles all fulfil the same function. It would probably be a mistake to assume that they did. The Clava circles are sepulchral; the two inner ones are the bounding kerb of a cairn and the kerb of the chamber under the cairn. On the other hand, we have now in Southern England an extensive group of circular monuments, some of them fairly regular, of the same type as Stonehenge I. Penannular ditches enclose rings of holes which contained (although not dug for that purpose) cremated human bones and had apparently never held any other timber posts or stones, so that they could not be used for sighting. One feels that these earthen monuments of Lowland Britain cannot be separated functionally from the stone monuments erected in more stony and rocky country.

We archaeologists are always grateful to collaborators from other disciplines and I am extremely grateful to the Society for giving me the privilege of hearing this paper.

Dr. IRWIN: I should like to ask two questions, one of a statistical and the other of a non-statistical nature. I think I understood Fig. 7 very well, but I was just a little puzzled about the rising and setting sections of the diagram. I can understand that in the case of the sun or any star the declination corresponding to its direction varies according as it points to the rising or to the setting sun or star; but for some of these observations which did not come opposite any star at all, how did Professor Thom decide whether to plot them as rising or as setting?

The other question I ask with caution. Supposing this astronomical theory is in fact true, how did these people round about 1800 B.C. get their astronomical knowledge? Did the Chaldeans know astronomy at that time? Was there any contact with the east? Could their knowledge have spread across the seas? It would be extremely interesting if somebody could tell us whether anything is known of such movements.

Professor THOM subsequently replied in writing as follows:

Professor Kendall raises an interesting point when he suggests that the variance should increase with the diameter. Does the fact that better agreement is found with the Quantum Hypothesis for circles over 80 ft. diameter than for circles under 80 ft. indicate that in fact the variance does *not* increase? Should this be substantiated by further evidence it seems to me to show that the erectors actually used measuring rods and did not depend on "laying individuals end to end" or simple pacing. I was interested in Professor Kendall's experiment showing the "catches" obtained by taking random azimuths and converting to declinations. I believe that otherwise his calculation followed mine and as he used the same pockets the results should be comparable. If, as my results suggest, outliers and alignments were erected to indicate the rising points of certain first magnitude stars, then one should try to find a reason. There is perhaps an *a priori* reason in that there are a great number of records from the Mediterranean region of the year being dated by the heliacal and antiheliacal rising or setting of certain stars and it would seem reasonable to mark the rising points in some way. Accordingly I made a study of the conditions which would make a star suitable for dating by this means. But I did not find a very good correlation with the stars most frequently indicated by the stones. We are thus thrown back on the explanation that the stars were used as timekeepers throughout the night. This seems a more reasonable explanation because in northern latitudes the day of the year is much more accurately indicated by the setting point of the sun on the horizon than by heliacal risings. Need we be surprised that Sirius did not have many indicators? Its rising point is sufficiently well indicated by Orion's belt which rose some time before Sirius itself. I sympathize with Professor Kendall in still having doubts. All I will say is that I think there is sufficient evidence in favour of an astronomical hypothesis to warrant further investigation. I think my use of the words "within reason" excludes Professor Kendall's suggestion that "if one took enough stars one would get a perfect catch".

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I agree with Mr. Hammersley's remark that the data are definitely limited. Nevertheless, I hope to be able to survey a good many more sites; there are, I understand, many in Ireland. I feel that perhaps one should try to evolve a method whereby one could examine and compare with the site-plans every reasonable geometrical construction which could have been carried out on the ground with stakes and rope. In this connection I should perhaps mention that since the paper was written I found a circle on the moor above Boot which is practically identical in size and shape with the prototype at Castle Rigg. Here, again, many of the construction points are marked. Unfortunately this circle is less well preserved than Castle Rigg.

At the time I analysed the Quantum Hypothesis for the diameters I realized to some extent the dangers to which Mr. Broadbent draws attention, but I could see no alternative to dividing the data into two by some arbitrary method. Since I had already noticed the 5½-ft. unit, any method of division at this stage is open to criticism. There is, however, no objection on this ground to the data given in the Appendix since nearly all these were collected after I had analysed my own data. I gather from Mr. Broadbent's remarks that a good deal of work is proceeding on the methods by which the Quantum Hypothesis can be more rigidly examined in a given case. In the meantime I am surveying more circles and so hope to produce an independent check.

I am glad to see that Professor Childe mentions the possibility that the circles were not all built to fulfil the same function; to one who has visited as many as I have, it becomes apparent that the circles themselves differ in more ways than can be described simply in terms of diameters, stone sizes, etc. Thus I think I am right in saying that what I would call the smaller or poorer circles seldom have outliers. Professor Childe's point answers to some extent the difficulty raised earlier by Professor Kendall, i.e. that *all* the pointers are not explained by the rising points of first magnitude stars. In fact some of the stones which I have assumed to be outliers may be the remnants of some entirely different construction, or three stones in line may have been originally part of a circle. I agree with Professor Childe that many of the monuments are so badly knocked about that it is impossible to determine an accurate diameter. It was for this reason that I resorted to a statistical method of calculating the diameters. I wished to obtain an objective value which would be unaffected by my preconceived ideas. The fact that I state the diameters to 1/10 ft. does not mean that I believe that I know them individually to this accuracy; I do not. I mostly used a linen tape which was liable to stretch or shrink. Other observers may find slightly different diameters, but I cannot see how my results can be biased in favour of a quantum hypothesis. As for the possibility of changes in the contours of the countryside, I do not think this likely to bias the astronomical arguments one way or the other. Geologists do not claim any serious movements, and the elevation of a horizon by trees will only affect the results seriously if the horizon is near. Many of these sites are on elevated plateaus where the horizon is distant. It will be observed that I have assumed several lines to be one-directional; in most cases the reason was that in the other direction the horizon was too close. A more serious factor in my opinion is the possible local distortion of the alignments by earth movements. I think that at present it is not possible to decide on an exact date by radio-carbon methods. The date of 1850 B.C. obtained from charcoal samples from Stonehenge has an uncertainty of ± 275 years, according to W. F. Libby in the January, 1954, number of *Endeavour*.

The answer to Dr. Irwin's question about the rising and setting is simply that for azimuths from 0–180 the alignment indicates a rising star and for those from 180–360, a setting. I am quite unable to deal with the contacts which these people may have had with the East. I would point out that for a people living without artificial illumination the face of the sky is a much more important factor than for modern man, especially during the long winter nights of these latitudes. To a people who were evidently developing the rudiments of geometry, the movements of the stars must have presented a continual challenge.

As a result of the ballot taken during the meeting the candidates named below were elected Fellows of the Society:

Eric Broughton.
Shriniwas Bhamburkar.
Stanley Frank Burgin.
Harold Park Cooper.
Desmond Alfred Dean.
Jacques-Paul Desabie.
Bryan Douglas Haig.
Henry William Haskey.
Ivor Hodges.
Douglas Hugh Johnston.
Faiz Shukri al Khuri.
Geoffrey Maynard Pacey.
Indrakenty Rao.
Norman James Royce.
Kenneth Sweeting.
Graham Turner.

Corporate Representatives

Harold Nabb, *representing* the South Western Gas Board, Bath.
Paul Newman, *representing* Aspro Ltd.

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A Method of Labour Turnover Analysis

By K. F. Lane and J. E. Andrew

[Read before the Royal Statistical Society, April 20th, 1955,
the President, Lord Piercy, C.B.E. in the Chair]

SUMMARY

The increased importance of labour turnover analyses in industrial establishments is stressed, and the broad objects of such investigations are outlined. Critical examination of the generally accepted labour turnover rate as a measure of employee stability has shown that it is not satisfactory, and Section I of the paper is devoted to an alternative method of analysis.

The probability of an employee leaving is expressed as a function of his length of service, and two methods of estimating this function are given. One involves the following through of a sample of entrants giving a survival curve, while the other uses census data in arriving at a stability curve.

Section II gives examples of the application of both methods, mainly to data collected in The United Steel Companies Limited but also to data from other sources. In practice both curves have been found to be approximately log-normal, and this assumption has simplified the calculation of an expectation of service which is proposed as a single measure of labour stability. Differences in stability between institutions, between departments within an establishment, and the effect of living circumstances and age upon the probability of leaving are illustrated.

Final sections of the paper deal with tests of significance on the goodness of fit to the log-normal assumption, between groups of men and between years. In conclusion the form of the stability curve is discussed, and some refinements to be made to the routine data collected are given.

Introduction

The replacement of labour in an industrial concern is a process which creates a hidden expense that can be considerable. The economics of the situation have been studied in some detail and it is not part of our present purpose to re-examine them, but it may be mentioned that each new employee has at least to accustom himself to his new environment and frequently also has to be trained. Thus, for a period at the beginning of his service, his output is necessarily low in quantity and perhaps in quality as well.

This fact has been increasingly appreciated during recent years for reasons which probably include the full employment conditions that have prevailed since the war and the drive for greater efficiencies. Thus, labour turnover analyses have assumed a position of importance and turnover figures have been extracted for many industries. The British Institute of Management, for instance, have issued a small booklet (Personal Management Series 1) drawing attention to the magnitude of the problem and in 1949 and 1950 they conducted a national turnover survey.

The purpose of labour turnover analyses cannot be defined to within narrow limits, but it may be stated as a general principle that they endeavour to paint as comprehensive a picture as possible of the leaving structure of the labour force for the benefit of the labour management. An exhaustive analysis should obviously compare the stabilities of employees in different works, in different departments and in different types of employment. It should also assess the effects of living circumstances, age, home area and travelling facilities and should go as far as possible towards an explanation of any variations in leaving rates. From such a detailed study one would expect also to be able to make estimates, for a short period ahead at least, of the number of leavers and the number of engagements required to either maintain or build up a particular section.

It is not the principal object of this paper to give the results of such an analysis, but rather to describe a method which has been developed for deriving the results from an adequate body of data. Over the last two years the authors have been engaged upon a survey of the larger branches

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of The United Steel Companies Limited, and they found that it was not a simple matter to answer even such an elementary question as, say, "Do employees leave more readily from blast furnace departments than from rolling mills?"

The method does not pretend to be a complete and precise solution to a problem which is complex and which, anyway, is always limited by the nature of the data available. It is simply an attempt at devising a logical procedure which will yield valid although approximate answers.

The paper is in two sections, the first describing the method and the second giving some applications.

SECTION I. METHOD

Basis of Method

A study of the objects of a turnover analysis makes it clear that, once the leaving process in a single group is understood, they can all be achieved by comparing groups. The effects of living circumstances, for instance, may be investigated by comparing a group of married men with a similar group of single men, or a group of married men living in hostels with a similar group living in their own homes. Thus, fundamentally, the elementary question mentioned in the introduction is the only question, and its answer is the key to the problem.

First, though, the leaving structure of a homogeneous group must be examined and stability defined. This work forms the main body of the paper.

Labour Turnover Rates

The stability, or rather instability, of a group of employees is usually measured by a labour turnover rate or index. This is defined as the number of leavers during a period expressed as a percentage of the average number of persons employed during that period. In order to make several rates directly comparable each is normally multiplied by the appropriate factor to correct it to an annual basis.

Indices in this form have been extensively calculated and quoted in surveys such as the one by the British Institute of Management, to which reference has already been made. They have the merits of being simple to evaluate and requiring only elementary data. They also have, though, one considerable disadvantage; they can be entirely deceptive.

This fact is probably generally appreciated, but nevertheless, an example will perhaps not be out of place. The annual turnover rates for two departments in a branch of The United Steel Companies Limited were found to be 8·8 per cent. and 17·3 per cent. From these figures an obvious deduction would seem to be that the former department was the more stable. A closer examination, though, revealed that it was, if anything, the less stable and estimates of the respective expectations of service in the two departments were 5 and 7 years—this statement is discussed in detail later.

The reason for this apparent anomaly is that the probability of an employee's leaving is strongly dependent upon his length of service. In general, the newer he is to the work the more likely he is to leave, so that departments with a high proportion of short service staff tend to have high turnover rates whether or not the men are in fact less stable. In the example just quoted, the second department had just been expanded with the result that the average numbers of men with less than one year's length of service and with greater than one year's length of service were 26 and 1,091 respectively for the first department and 50 and 332 for the second. The discrepancy between the proportions of short-service staff was, therefore, large and in fact it was more than sufficient to account for the difference in the turnover rates.

Probability of Leaving Functions

Considerations such as the one which has just been discussed lead to an appreciation of the importance of the probability of an employee's leaving expressed as a function of his length of service.

If a probability of leaving function can be associated with each member of a group then the changing structure of the group is a stochastic process. A knowledge of the entrants and their associated functions is sufficient to determine statistically the system, and provided the number of men is large enough its behaviour may be predicted with reasonable accuracy.

Viewed from this angle the situation is complex unless these leaving functions share certain

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properties. A simplifying assumption that does seem reasonable is that similar men joining at the same time (or within a certain short period) have identical associated curves. This assumption is made at the beginning of the mathematical sketch of the position which is to be given.

Consider a group of employees which is homogeneous in the sense that the behaviour of its individuals can be described in terms of probability of leaving functions which depend only upon their lengths of service and times of entry. Define four functions as follows:

$E(t)$ Entrants' function: Number of men engaged between times t_1 and t_2 =

$$\int_{t_1}^{t_2} E(t)dt.$$

$f(x, t)$ Probability of leaving function: Probability of entrant at time t leaving with a length of service between x_1 and x_2 =

$$\int_{x_1}^{x_2} f(x, t)\, dx.$$

$L(x, t)$ Leavers' function: Number of men leaving between t_1 and t_2 with lengths of service between x_1 and x_2 =

$$\int_{t_1}^{t_2} dt \int_{x_1}^{x_2} L(x, t)\, dx.$$

$F(x, t)$ Length of service distribution: Number of men at time t with lengths of service between x_1 and x_2 =

$$\int_{x_1}^{x_2} F(x, t)\, dx.$$

Then these four functions completely describe the system. They are not, however, independent.

The men who join in the interval dt between t and $t + dt$ number $E(t)\, dt$. After a lapse of time x a proportion $\int_0^x f(\alpha, t)\, d\alpha$ will have left and the remainder $E(t)\, dt \int_x^\infty f(\alpha, t)\, d\alpha$ will form the group with lengths of service between x and $x + dt$ at time $t + x$.

Hence
$$F(x, t + x) = E(t) \int_x^\infty f(\alpha, t)\, d\alpha.$$

Putting
$$\varphi(x, t) = \int_x^\infty f(\alpha, t)\, d\alpha$$

and transforming from $t + x$ to t, this may be written:

$$F(x, t) = E(t - x)\, \varphi(x, t - x) \quad . \quad . \quad . \quad . \quad . \quad 1$$

Further, a man with length of service x at time t has a probability

$$\frac{f(x, t - x)}{\varphi(x, t - x)}\, dt$$

of leaving before time $t + dt$.
Hence

$$L(x, t) = F(x, t) \frac{f(x, t - x)}{\varphi(x, t - x)} \quad . \quad . \quad . \quad . \quad . \quad . \quad 2a$$

$$= E(t - x)\, f(x, t - x). \quad . \quad . \quad . \quad . \quad . \quad 2b$$

With the additional assumption (an unrealistic one) that $f(x, t)$ is independent of t, i.e. that all men have the same probability of leaving function, these two formulae simplify to:

$$F(x, t) = E(t - x)\, \varphi(x)$$

and

$$L(x, t) = E(t - x)\, f(x).$$

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If a new group starts with a certain level of manning and if sufficient entrants are brought in to maintain this level then, as time passes, the members will seep into the longer length of service groups until, provided $f(x)$ satisfies certain conditions, a position of equilibrium is reached. Then:

$$F(x) = E\,\varphi(x) \text{ and } L(x) = Ef(x).$$

This situation is of little practical importance, but it has been mentioned here because it is of some interest as a standard with which actual situations could be compared.

Survival and Stability Curves

The previous section has shown the manner in which the probability of leaving functions underlie the leaving process within a group. Now, in labour turnover analyses, it is necessary to describe the position of a group at a particular time, so that the problem is to deduce the forms of the probability of leaving functions, or the relevant parts of them, from a set of data. Stated in this way, the problem is clearly similar to that of constructing mortality tables, but it possesses two distinguishing features of importance.

Firstly, mortality rates change as time passes, but in Western countries at least, they do not fluctuate widely; instead they follow a generally downward trend from year to year. Leaving rates can, however, vary up and down comparatively widely and rapidly, because they are dependent on economic conditions.

Secondly, the nature of the data and of the results required differ. A considerable weight of financial business rests upon the foundations of the mortality tables and they must, consequently, be accurate. The methods developed for constructing them incorporate many detailed refinements and the data are always ample. In contrast, labour stabilities need only be estimated approximately and moreover the data are inevitably comparatively elementary.

Two standard actuarial methods exist for compiling mortality tables, the method of following individuals and the census method. Both of these can be adopted to labour turnover work and they will be discussed in turn.

Consider the batch of individuals who join during a certain period of time. If this period is sufficiently short the probability of leaving function may be treated with reference only to duration of employment, so that:

$$L(x, t) = E(t - x)\,f(x).$$

Integrating both sides:

$$\int_{-\infty}^{\infty} dt \int_{0}^{x} L(\alpha, t)\,d\alpha = \int_{-\infty}^{\infty} E(t)\,dt\,(1 - \varphi(x))$$

i.e.

$$\varphi(x) = 1 - \frac{\displaystyle\int_{-\infty}^{\infty} dt \int_{-\infty}^{x} L(\alpha, t)\,d\alpha}{\displaystyle\int_{-\infty}^{\infty} E(t)\,dt}$$

Hence an estimate of $\varphi(x)$ is simply the proportion of the batch staying for a longer time than x. This, when plotted, is known as the survival curve for the batch.

Several authors have used this formula as it stands, including Greenwood and Smith (1936) and, more recently, Rice, Hill and Trist (1950). It is satisfactory as far as it goes, but it is by no means a complete solution because it does not describe the position of the whole group.

Suppose, for instance, labour turnover during 1953 is being studied and the history of the batch of entrants in 1949 is followed until 1954. Then the leaving structure of the group of men with between three and four years' length of service at the beginning of 1953 is fully understood but what about the remainder? Any inferences about them will clearly involve the assumption of time independence besides the extrapolation which will be necessary to cover the longer length of service groups.

Of course, these objections could be met by tracing the history of many batches instead of one. The method then becomes very cumbersome, though, and the census method presents a more satisfactory alternative.

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For this method the manning and leavers in length of service groups must be known. Let these groups be defined by:

$$x_o = 0 < x_1 < x_2 \ldots < x_n = p$$

where p is the maximum possible length of service and let the length of the rth interval, $x_r - x_{r-1}$ be 1_r. Let t_1 and t_2 be the times at the beginning and end of the period under review and denote by:

F_r the average number of men in the rth length of service group during the period.
and L_r the total number of leavers in the rth length of service group during the period.

From equation 2*a*

$$\frac{L(x, t)}{F(x, t)} = \frac{f(x, t-x)}{\varphi(x, t-x)}$$

Integrating both sides and putting $t_2 - t_1 = \tau$

$$\frac{1}{\tau}\int_{t_1}^{t_2} dt \int_{x_{r-1}}^{x_r} \frac{f(x, t-x)}{\varphi x, t-x)}\, dx$$

$$\div \frac{1}{\tau}\frac{1_r}{F_r}\int_{t_1}^{t_2} dt \int_{x_1}^{x_2} L(x, t)\, dx$$

$$= \frac{1_r L_r}{\tau\ F_r}$$

$$= \frac{I_r}{100}\, 1_r \text{ (say)}$$

provided all the 1.'s and τ are sufficiently small. Again, with the same proviso, $\varphi(x, t)$ and $f(x, t)$ on the left hand side of the equation may be taken as independent of t and equal to $\varphi_r(x)$ and $f_r(x)$ respectively, say, so

$$\log \varphi_r(x_{r-1}) - \log \varphi_r(x_r) \div \frac{I_r}{100}\, 1_r.$$

It will be seen that the quantity I_r is simply the labour turnover rate per unit time for the rth length of service group.

Although crude, the approximation is adequate if the number of men in each group is sufficiently large and if the length of service intervals are selected sensibly. τ can be conveniently taken as one year, and the properties of $f(x, t)$ have been found to be such that a chain of the x_r's on the following lines is satisfactory:

0, 1 month, 3 months, 6 months, 1 year, 2 years,
5 years, 10 years, 15 years, 20 years.

The critical portion of the curve is its beginning which must, therefore, be covered by a fine grouping. Later it changes more slowly and the intervals may be progressively expanded.

The average manning F_r in the denominator of the labour turnover rate may be estimated in several ways, of which the most common is to divide the sum of the mannings at the beginning and end of the period by two. This gives a good enough figure for the longer lengths of service, but some care is needed for the groups below one year.

The application of this method in practice yields a sequence of values for the differences $\log \varphi_r(x_{r-1}) - \log \varphi_r(x_r) = \delta_r$. Ignoring the suffixes of φ these equations may be solved to give $\varphi(x_o) = 1$, $\varphi(x_1)$, $\varphi(x_2) - \varphi(x_n)$ and the curve through these points will be called the stability curve for the group. It is not a proper probability of leaving function because it does not necessarily describe any individual's behaviour, but it is a composite curve constructed from segments of several such functions and it gives an immediate picture of the leaving process throughout the group.

Clearly, since stability is described by a functional relationship, it cannot be completely summarized by a single figure unless this relationship is of an elementary nature. Nevertheless it is convenient to have a statistic which in some sense is a measure of stability and the best for this

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purpose would seem to be an expectation of service analogous to the expectation of life in actuarial work.

It might be thought that a curve would be cumbersome to deal with in practice and that comparing groups and evaluating expectations of service would not be simple. However, in all the applications so far both the stability curves and the probability of leaving functions have been found to approximate to a familiar distribution.

SECTION II. APPLICATIONS

The following applications refer mainly to work carried out by the authors in conjunction with the Labour Departments of The United Steel Companies Limited, but certain other data have been included to show the general validity of some of the results. Both the census method and the method of following through a sample of individuals for a given period of time (engagement data method) have been used.

Collection of Data at United Steel Companies Ltd.

For the census analysis, two standard forms were drawn up during 1951 so that each of the four main branches could supply the relevant labour statistics at agreed intervals of time on a common basis. The first of these forms was designed to serve two purposes:

1. An annual return from each branch, giving the male weekly wage earning population over 21 years of age excluding staff. This total manning was divided into department groups and, within these groups, into three classifications of skill. Further subdivision within these groups was made into length of service, age and annual rate of earnings, the breakdown into length of service groups, which is the only factor of specific interest in this paper, being as follows:

0– 3 months	2– 5 years
3– 6 ,,	5–10 ,,
6– 9 ,,	10–15 ,,
9–12 ,,	15–20 ,,
1– 2 years	>20 ,,

2. This form has also been used to report the quarter yearly subdivision of adult male leavers into the above groups, and, in addition, into eleven reasons for leaving groups. Apart from the necessity of collecting this information for an analysis of labour stability, it was considered that other aspects, such as the ageing of the labour force over a long period of time, could be examined.

The second form was designed so that some measure of the variation in the leaving and engagement rate of adult males from one four-weekly period to another could be obtained. In this form, which is completed every four weeks by each branch, the number of engaged men and the number of leavers for each department is given, together with the departmental manning at the beginning and end of the period and any internal transfers which have taken place. It should be noted that the number of between department transfers is very small compared with the leaving and engagement rates, and they have not been classified as leavers in the individual department analyses.

For the engagement data method a one-yearly sample of engagements was chosen. It was considered that one year was the minimum period of time, partly from the point of view of acquiring sufficient data, and partly from the desirability of eliminating the effect of seasonal fluctuations in the leaving rate as far as was possible. The sample chosen covered the period 24th September, 1950, to 23rd September, 1951, which was the Company's financial year 1950/51, and the return was made in April, 1953. Consequently each entrant had had the opportunity of at least 18 months' service with the Company when the record was taken.

In order to carry out a detailed analysis into several factors which were thought to have an important effect upon labour stability, a considerable amount of information was collected, referring to such factors as each individual's length of service prior to leaving, his age at entry, his living circumstances and marital status, the distance of his residence from the works, his skill and reason for leaving. The very rare cases of redundancy and conscription were omitted from the subsequent analyses and, since retirement was non-existent in these data, the reasons for leaving included in the survey were roughly medical, own request, and, as occasionally occurred, severe infringement of regulations.

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TABLE 1

Branch A

1950/51 *Number Engaged* = 1161					1951/52 *Census Data*								
Length of Completed Service	*Number of Leavers*	*Cumulative Number of Leavers*	*Number Remaining*	*Remaining as Percentage of Engaged (Survival Curve)*	*Length of Service Groups*	*Manning* — *Start Period*	*Manning* — *End Period*	*Manning* — *Average*	*Number of Leavers*	*Annual Turnover Rate Per Cent.*	δ_r	$\log_e 10$ —*Cum.* δ_r	$\varphi(x)$ *as Percentage (Stability Curve)*
1 month	205	205	956	82·3									
2 months	128	333	828	71·3									
3 ,,	79	412	749	64·5	0– 3 mths.	184	292	238·0	406	170·59	·4265	1·8761	65·3
4 ,,	48	460	701	60·4									
5 ,,	44	504	657	56·6									
6 ,,	51	555	606	52·2	3– 6 mths.	175	132	153·5	128	83·39	·2085	1·6676	53.0
7 ,,	25	580	581	50·0									
8 ,,	24	604	557	48·0									
9 ,,	17	621	540	46·5	6– 9 mths.	152	157	154·5	33	34·30	·0858	1·5818	48·6
10 ,,	17	638	523	45·1									
11 ,,	17	655	506	43·6									
12 ,,	11	666	495	42·6	9–12 mths.	176	153	164·5	45	27·36	·0684	1·5134	45·4
13 ,,	14	680	481	41·4									
14 ,,	8	688	473	40·7									
15 ,,	5	693	468	40·3									
16 ,,	7	700	461	39·7									
17 ,,	5	705	456	39·3									
18 ,,	6	711	450	38·8									
2 years					1– 2 yrs.	390	463	426·5	75	17·58	·1758	1·3376	38·1
5 years	—	—	—	—	2– 5 yrs.	1235	1147	1191·0	169	14·19	·4257	0·9119	24·9
10 ,,	—	—	—	—	5–10 ,,	732	837	784·5	56	7·14	·3570	0·5549	17·4
15 ,,	—	—	—	—	10–15 ,,	1616	1459	1537·5	61	3·97	·1984	0·3565	14·3
20 ,,	—	—	—	—	15–20 ,,	785	795	790·0	26	3·29	·1646	0·1919	12·1
					>20 ,,	1722	1690	1706·0	61	3·58	—	—	—
					Total	7167	7125	7146·0	1080	15·11	—	—	—

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TABLE 2

Branches B, C and D

Length of Completed Service	Branch B: 321 Engaged					Branch C: 491 Engaged					Branch D: 206 Engaged				
		Remaining as Percentage of engaged	1951/52 Census Data				Remaining as Percentage of Engaged	1951/52 Census Data				Remaining as Percentage of Engaged	1951/52 Census Data		
	Number of Leavers		Average Manning	Number of Leavers	$\varphi(x)$ as Percentage	Number of Leavers		Average Manning	Number of Leavers	$\varphi(x)$ as Percentage	Number of Leavers		Average Manning	Number of Leavers	$\varphi(x)$ as Percentage
1 month	32	90·0				46	90·6				5	97·6			
2 months	21	83·5				37	83·1				9	93·2			
3 ,,	10	80·4	52·0	55	76·8	23	78·4	82·0	71	80·5	8	89·3	84·0	43	88·0
4 ,,	9	77·6				25	73·3				7	85·9			
5 ,,	10	74·5				19	69·5				10	81·1			
6 ,,	8	72·0	58·0	25	68·9	12	67·0	65·0	35	70·4	1	80·6	48·5	19	79·8
7 ,,	8	69·5				13	64·4				3	79·1			
8 ,,	10	66·4				7	62·9				4	77·2			
9 ,,	6	64·5	55·0	17	63·8	8	61·3	70·0	20	65·5	3	75·7	71·0	19	74·6
10 ,,	2	63·9				2	60·9				3	74·3			
11 ,,	5	62·3				9	59·1				4	72·3			
12 ,,	3	61·4	45·5	11	60·1	7	57·6	76·0	22	61·0	1	71·8	31·5	10	68·9
13 ,,	6	59·5				4	56·8				1	71·4			
14 ,,	0	59·5				3	56·2				1	70·9			
15 ,,	1	59·2				6	55·0				0	70·9			
16 ,,	3	58·3				1	54·8				2	69·9			
17 ,,	2	57·6				2	54·4				0	69·9			
18 ,,	5	56·1				6	53·2				0	69·9			
2 years			190·5	29	51·6			249·5	46	50·7			164·5	18	61·8
5 ,,	—	—	404·5	31	40·9	—	—	756·5	75	37·7	—	—	713·0	66	46·8
10 ,,	—	—	557·0	20	34·2	—	—	577·0	53	23·8	—	—	1556·5	85	35·6
15 ,,	—	—	204·0	12	25·5	—	—	978·5	41	19·3	—	—	796·5	29	29·7
20 ,,	—	—	197·0	9	20·2	—	—	618·0	15	17·1	—	—	700·5	21	25·5
> 20 years	—	—	665·0	30	—	—	—	757·0	32	—	—	—	1524·0	57	—
Total	—	—	2428·5	239	—	—	—	4229·5	410	—	—	—	5690·0	367	—

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Examination of Data

As an example of the estimation of $\varphi(x)$ by the two methods, Branch A, which showed the lowest stability, has been chosen. The results from the 1950/51 sample of engagements are on the left in Table 1, while the corresponding estimates of $\varphi(x)$ expressed as a percentage, and obtained from the 1951/52 data supplied on the standard forms, are shown in the final column of the table.

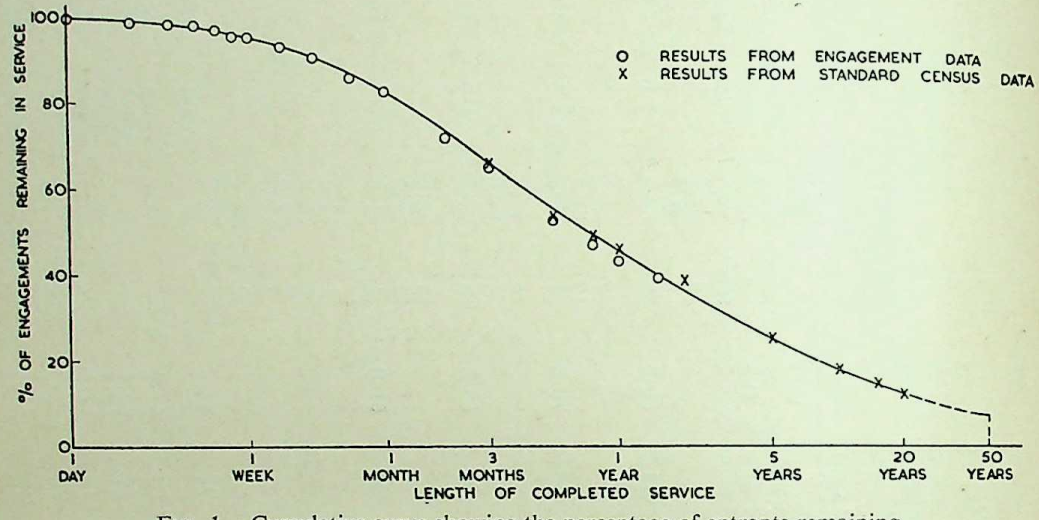


FIG. 1.—Cumulative curve showing the percentage of entrants remaining in service after any length of service at branch A.

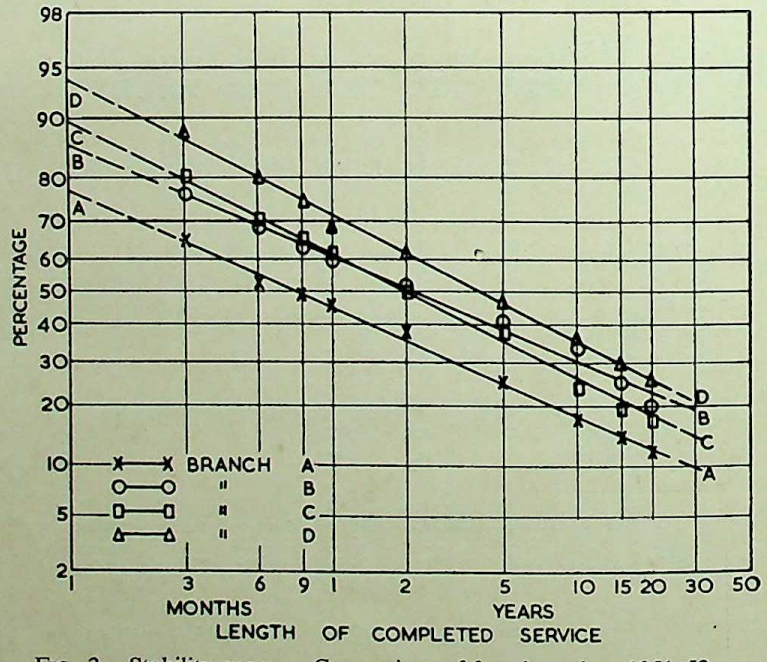


FIG. 2.—Stability curves. Comparison of four branches, 1951–52.

The census data cover a rather different period of time from the engagement data, and there is, therefore, no reason to expect identically similar results from the two methods. However, since the national demand for labour and its availability did not vary substantially over the period chosen, some reasonably close agreement should be apparent, and the actual results may be seen

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to compare quite well. It is important to note in this table that, even over the period of one year, the distribution of manning in the length of service groups can vary appreciably. The resultant error in the estimate of $\varphi(x)$ from such inevitable errors in the estimate of the average manning may be substantial in the low length of service groups where the manning is of the same order of magnitude as the leavers.

Similar calculations were made for the remaining three branches, and the results are shown summarized in Table 2, the agreement between the two methods of estimating $\varphi(x)$ again being quite satisfactory. It is now clear that the employees exhibit the greatest stability at branch D

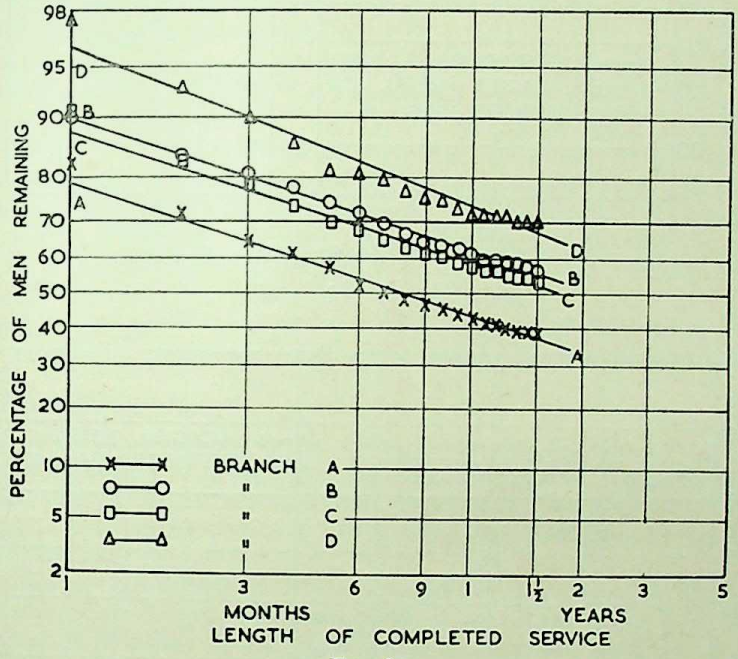


FIG. 3*a*

FIGS. 3*a–d*.—Survival curves. Comparison of four branches, 1950–51. Works E.

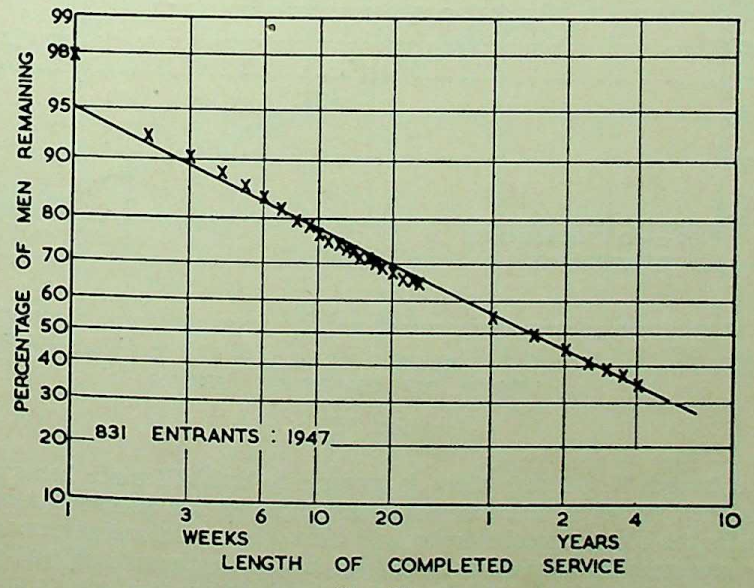


FIG. 3*b*

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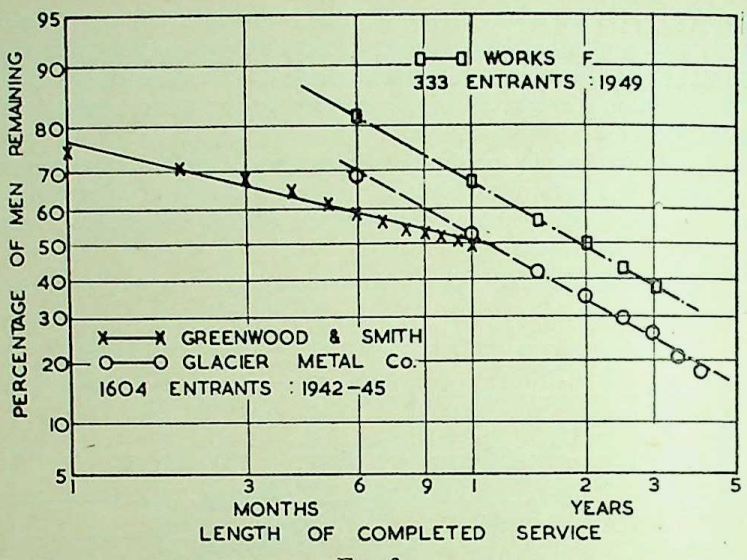


FIG. 3*c*

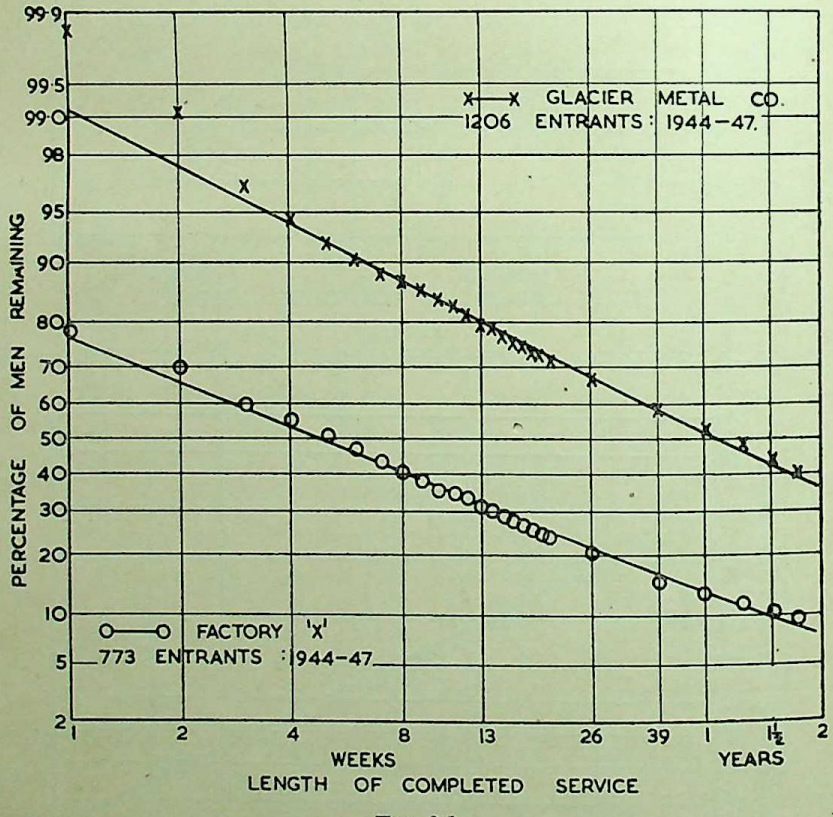


FIG. 3*d*

and the least at branch A, whereas there is apparently little difference between B and C. It should be mentioned, however, that even the annual turnover rate at branch A is lower than the overall average for the iron and steel industry as indicated by several recent surveys.

In order to represent the survival and stability curves diagrammatically, a logarithmic scale for length of completed service was chosen so that the short length of service section, where the

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greatest change in $\varphi(x)$ occurs, would be expanded and the later stages contracted. Again, taking branch A as the example, the results from the analysis of the engagement data, covering the period of 1 day to 18 months were plotted in Fig. 1, and the stability curve from the census data added. A smooth curve has been drawn "by eye" through the points, extrapolated along the dotted line to 50 years' service and then brought vertically down, it being considered that this service is about the maximum that an employee can give before retirement.

Now the general shape of this cumulative curve appears similar to a cumulative normal distribution curve. Consequently the results from the census data were tentatively plotted on 3-cycle logarithmic probability paper and the points found to group closely about a straight line. The stability curves for the other three branches were plotted in this manner, and Fig. 2 shows that straight line gives a good fit to all four sets of points.

The engagement data were analysed in a similar fashion, and the diagram, Fig. 3*a*, shows the resultant survival curves. Straight lines have been fitted "by eye" to the points, but it may be seen that, for three branches (A, C and D) the data show slight deviations of a similar nature from the lines. The actual percentage remaining is, for these three branches, higher than expected after 1 month and 18 months, and lower than the expected values over the central period. These deviations are probably non-random, and may conceivably have arisen by fluctuations in the probability of leaving function with time. It is not difficult to see that a progressive increase in stability over the period during which the data were collected would have resulted in a composite survival curve similar to the general shape of those in Fig. 3*a*.

Figs. 3*b*, *c*, and *d* show survival curves from other sources, the data made available covering varying periods of service. In general the fit of the straight line is quite satisfactory.

The Log-Normal Distribution

The fact that stability and survival curves are approximately log-normal is obviously of utility for the graphical comparison of groups and for interpolation and extrapolation purposes. Its greatest advantage, though, is that it enables the "expectation of service" to be calculated fairly easily and, as has already been mentioned, this statistic would seem to be the best single figure with which to measure stability.

Before a formula can be derived some assumption must be made about the behaviour of the curve for large values of the length of service because it cannot be extrapolated to infinity. One which has the virtue of simplicity is that there exists a maximum length of service p at which employees must retire, so that:

$$f(x) = \frac{1}{\sigma x\sqrt{2\pi}} \exp\left(\frac{-(\log x - m)^2}{2\sigma^2}\right) \qquad 0 \leqslant x < p$$

and

$$= 0 \qquad x > p$$

$$\text{prob. } (x = p) = \int_p^\infty \frac{1}{\sigma x\sqrt{2\pi}} \exp\left(\frac{-(\log x - m)^2}{2\sigma^2}\right) dx$$

These are unlikely to be the actual circumstances but, provided the assumption is used consistently for the calculation of all the expectations of service, they should be comparable.

Let $\chi(x)$ be the frequency function of the log normal distribution with mean m and variance σ^2 and let α be its mean so that:

$$\log \alpha = m + \tfrac{1}{2}\sigma^2.$$

Then, if s_r is the expectation of service (from joining) of a man who has already completed r years' service:

$$s_r \int_r^\infty \chi(x)\, dx = \int_r^\infty x f(x)\, dx$$

$$= \int_r^p \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{1}{2\sigma^2}(\log x - m)^2\right) dx$$

$$+ p \int_p^\infty \chi(x)\, dx$$

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Now

$$\int_r^p \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{1}{2\sigma^2}(\log x - m)^2\right)dx$$

$$= \alpha \frac{1}{\sigma\sqrt{2\pi}} \int_{\log r}^{\log p} \exp\left(-\frac{1}{2\sigma^2}(y - \overline{m + \sigma^2})^2\right)dy$$

$$= \alpha \left(\overline{N(m + \sigma^2)}\right)_{\log r}^{\log p}$$

Similar expressions may be derived for the other two integrals yielding finally:

$$s_r = \frac{\alpha \left(N(\overline{m + \sigma^2}, \sigma)\right)_{\log r}^{\log p} + p\left(N(m, \sigma)\right)_{\log p}^{\infty}}{\left(N(m, \sigma)\right)_{\log r}^{\infty}}$$

Expectations of Service

From the data in the preceding diagrams, the values of m and σ have been estimated and the expectations of service calculated. These results are shown in Table 3 and the service rounded off to the nearest half year. Thus, if the probability of leaving function were independent of t, the expectation of service given by recent entrants to, say, branch A would be expected to be about one half of that for branch D. Clearly, it is extremely improbable that this function will remain sensibly constant over such a long period, but it is suggested that the figures quoted do represent, in a single measure, the comparative stability of different groups of men at any time.

TABLE 3

Institution	*Engagement Data* m	*Engagement Data* σ	*Engagement Data* Expectation of Service Years	*Census Data* m	*Census Data* σ	*Census Data* Expectation of Service Years
United Steel Co. Ltd. — Branch A	−0·46	2·62	6	−0·39	2·91	7
United Steel Co. Ltd. — Branch B	0·77	2·56	11	0·77	2·92	12
United Steel Co. Ltd. — Branch C	0·54	2·60	9½	0·66	2·42	9½
United Steel Co. Ltd. — Branch D	1·35	2·15	12½	1·35	2·47	13½
Works E	0·36	2·59	7½			
Works F	0·65	1·47	5			
Glacier: 1942–45	0·10	1·49	3			
Glacier: 1944–47	0·11	1·72	4			
Factory "X": 1944–47	−2·39	2·18	1			
Greenwood and Smith	0·06	3·29	10			

The range of calculated expectations of service is high, varying from as little as 1 year for Factory "X" to as much as 12½ years for branch D. It may also be seen that the agreement between the results from the engagement data method and the census method is quite satisfactory for the four branches of The United Steel Companies Limited. The two estimates of m for each branch show particularly good agreement.

TABLE 4

Expectation of Service—Years

Length of Completed Service—Years	*Branch* A	B	C	D
At engagement	7	12	9½	13½
¼	11	15½	12	16
1	15½	19½	15½	19
5	26	29½	25½	28½

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This expectation of service has also been calculated for employees who survive varying lengths of service with the four branches, and the results are presented in Table 4. Thus at, say, branch A, the figure for the whole engagement group is 7 years, whereas for those who are still in service after 5 years (24·5 per cent. of the entrants), it is equal to an additional 21 years, i.e. 26 years in all. In fact there is little difference between the branches in the expectations of service of men who have already survived 5 years.

Departmental Comparisons

In Section I, an illustration was given of how deceptive a simple comparison of annual labour turnover rates can be. The analysis of the two departments quoted is considered here in more detail.

The departments chosen are both at branch A and, from the turnover rates, men in A1 appeared to be about twice as stable as those in A2. The average total manning for the year 1951/52 and the number of leavers from the census data are shown in Table 5 with the resultant labour turnover rates.

TABLE 5

Department	A_1	A_2
Total manning . . .	1117	382
Number of leavers . . .	98	66
Annual turnover rate . .	8·8	17.3

Calculation of the stability curves, however, gave the diagram shown in Fig. 4, where it may be seen that the men of department A1 were, in fact, less stable than those in A2. The corresponding estimates of the expectations of service are 5 and 7½ years for A1 and A2 respectively, i.e. the stability of men in A1 is only about two-thirds of that for A2.

This is a particularly striking example of the erroneous conclusions that may be drawn solely from examination of turnover rates. The discrepancy has arisen from the dissimilarity in the distribution of manning in the length of service groups between the two departments. Fig. 5, where the cumulative percentage of the manning with less than a given length of service is plotted against the length of service on a logarithmic scale, illustrates this. It is clear that A2 had a much greater proportion of its labour force in the low service groups than had A1, a fact which resulted partly from a recent expansion of the former department and partly from a policy of replacing only a proportion of the leavers from the latter during 1950/51. Such a difference has inevitably resulted in the turnover rate indicating a spurious labour stability which is too high for A1 and too low for A2.

Factors Influencing Labour Stability

The preceding work has already illustrated two factors which may affect the stability of labour. Firstly, a marked difference between institutions has been shown to exist which could be attributable to the type of work carried out, the managerial policy, the wage rate and the availability of labour in the immediate vicinity. Differences in local labour availability and housing facilities have, in fact, been found to be mainly responsible for the differences in stability between the four branches of The United Steel Companies Limited. Secondly, there can exist, within works, departmental differences in labour stability, caused by such factors as the working conditions and level of earnings.

Superimposed upon these influences, there clearly exist intrinsic differences between men. Age, living circumstances and the grade of skill are only three of the many variables which may be expected to affect the probability of leaving, and, though it is not the main object of this paper to discuss the examination of such factors, one of the more interesting analyses has been included as an example.

Branch A, owing to its locality, experiences considerable difficulty in replacing its leavers from locally recruited labour. Consequently a substantial proportion of the entrants originate from outside a convenient daily travelling radius, and provision for their housing has had to made nearer to the works. Lodging accommodation has been found for some, but, for many, hostels have provided the only solution. An analysis of the effect upon stability of different

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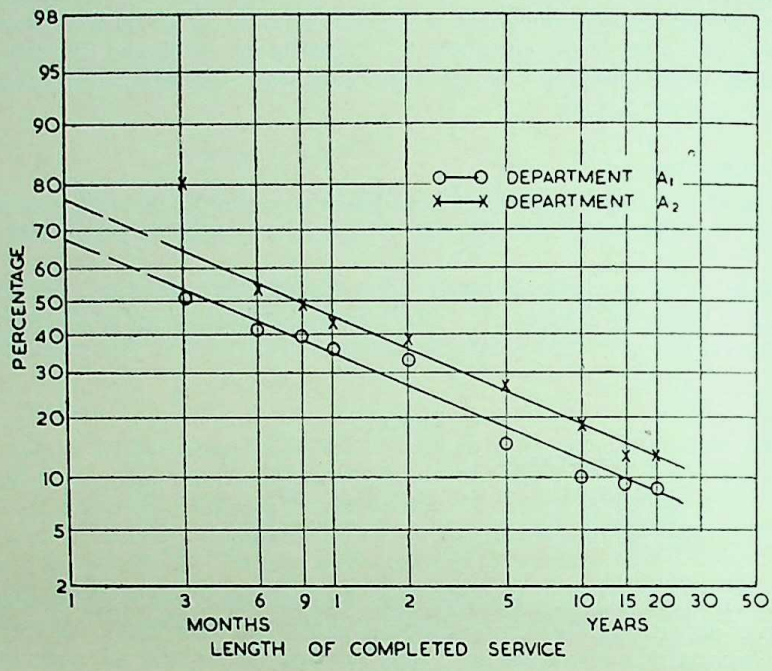


FIG. 4.—Stability curves. Comparison of two departments.

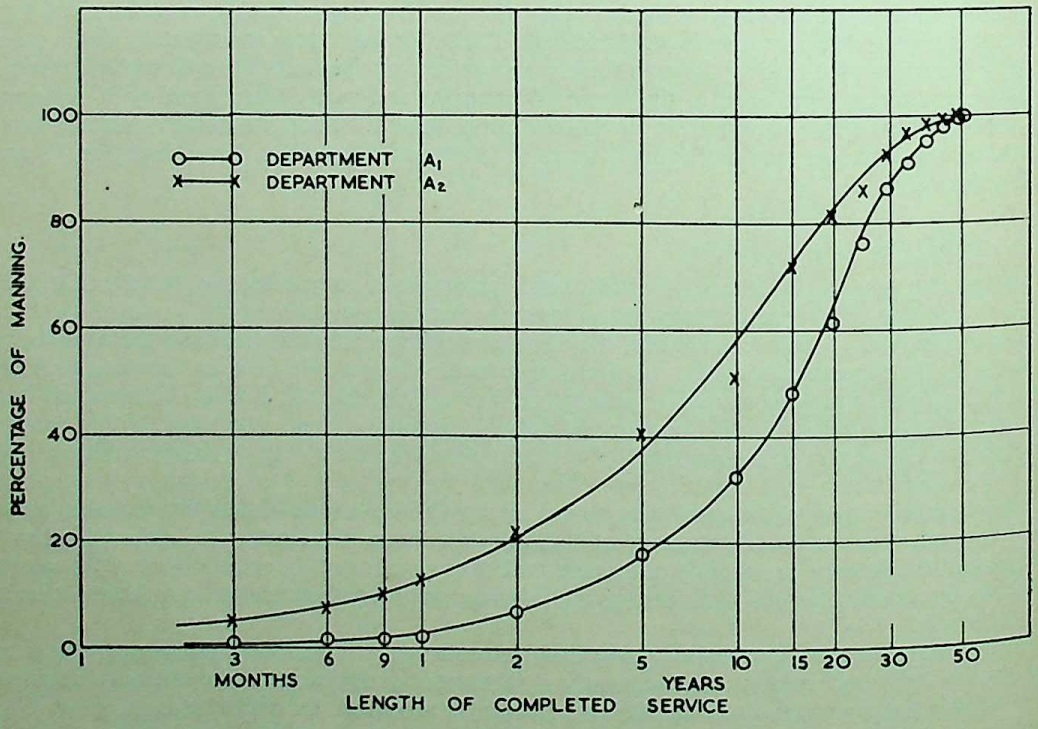


FIG. 5.—Cumulative length of service distribution curves for two departments.

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living circumstances was, therefore, thought to be of some importance, and Fig. 6 shows a sample of the survival curves obtained from this examination of the engagement data.

Four groups of men have been considered, viz. married men living in their own homes and in hostels, and single men living with their parents and also in hostels. It may be seen from the diagram that there is a marked difference between these groups, married men in hostels being, initially, the least stable, whilst married men in their own homes exhibit the greatest stability. It will be noted, however, that although the leaving rate of single men in hostels is not, at first, as high as that for married men in similar accommodation, their stability does not rise as quickly

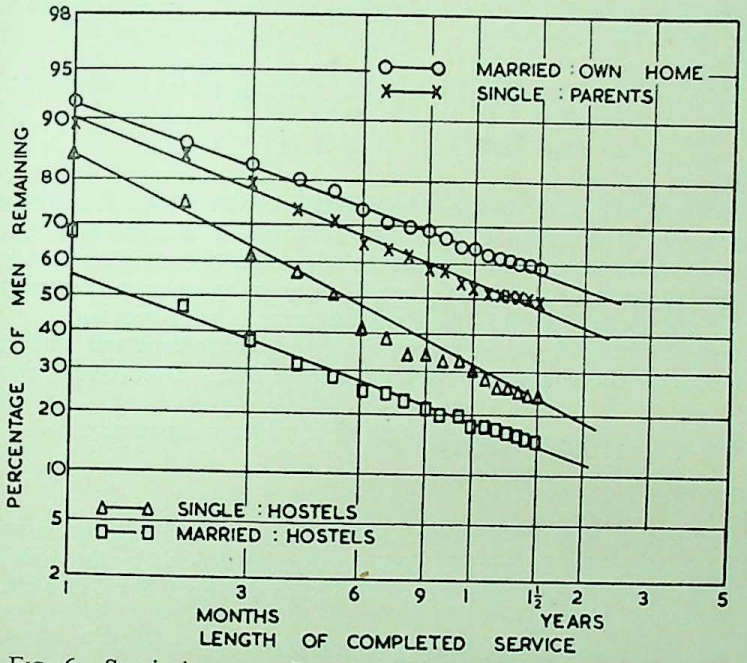


FIG. 6.—Survival curves. Branch A: Effect of living circumstances.

with increasing length of service. The estimates of m, σ and the expectations of service for the four groups are shown in Table 6.

TABLE 6

Living Circumstances	m	σ	*Expectation of Service—Years*
Married—own home . .	0·88	2·46	11
Single—parents . . .	0·26	2·17	6½
Single—hostels . . .	−0·82	1·66	1½
Married—hostels . .	−2·15	2·39	1½

Examination of the age at entry revealed, as might be expected, that the average age of single entrants was significantly lower than that of married men. Thus, if age affects stability, the comparisons of married and single men in the preceding work will be biased. The age-group of 21–29 years was selected, and the single men with parents again compared with married men living in their own homes as shown in Table 7. The difference in stability between these two groups is now greatly reduced, and it will also be seen that the expectations of service for this low age-group is less than for all ages combined.

This analysis has clearly shown the comparatively low expectation of service for men living in hostels. Whether or not this effect is directly attributable to their less attractive living conditions is, however, by no means certain since it is conceivable that some men who are willing to accept this type of accommodation are intrinsically less stable. Lower inherent stability, in fact, may be responsible for their living circumstances rather than the reverse.

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Another point that emerges from the work is the influence of age upon the probability of leaving. The stabilizing effect of increasing age has been found to exist at all four branches of The United Steel Companies Limited, both m and σ tending to increase with age at entry, as suggested by the results in Table 7.

TABLE 7

Living Circumstances	*Age-group—Years*	*Percentage of Total*	m	σ	*Expectation of service—Years*
Married—own home	All ages	100	0·88	2·46	11
Single—parents	,, ,,	100	0·26	2·17	$6\frac{1}{2}$
Married—own home	21–29	32·7	0·46	2·16	$7\frac{1}{2}$
Single—parents	21–29	82·5	0·11	2·15	6

Significance Tests

So far the goodness of fit of the lines to the points in the survival and stability curve diagrams has not been discussed. The reason for this omission is that it has not really been relevant. The only assumption which has been made is that the approximation to a straight line is sufficiently good to enable the log-normal formulae to be used in order to estimate an expectation of service, so that whether or not the fit is good in the statistical sense is not important.

However, significance tests between groups are clearly important and while studying these it is of interest to examine the straight line fit at the same time. Both types of test will therefore be illustrated.

Survival and stability curves can conveniently be considered separately.

(i) *Survival Curves*

The method of testing between groups is straightforward and consists simply of comparing the leavers in length of service categories. With categories defined by the divisions 1, 2, 4, 8, 12 and 18 months the comparison of two groups forms an ordinary 2×7 table for which χ^2 may be evaluated in the usual manner.

The branch survival curves of Fig. 3*a* may be considered as examples:

Between	B and C	$\chi^2 = 4{\cdot}6$	6 d.f	Not signficant.
,,	B and D	$\chi^2 = 19{\cdot}8$	,,	Significant at 1 per cent.
,,	A and C	$\chi^2 = 38{\cdot}4$	,,	Very significant.

Other comparisons are obviously significant.

The test of goodness of fit to the line is similar, the leavers in this case being compared with an expected number deduced from the line. With the same categories as before χ^2 has 4 degrees of freedom if fitting a line by eye is considered equivalent to estimating two parameters. The results for the branch curves are:

Branch	A	$\chi^2 = 44{\cdot}3$	4 d.f. Very significant.
,,	B	$\chi^2 = 3{\cdot}3$	,, Not significant.
,,	C	$\chi^2 = 9{\cdot}2$	,, Significant at 5 per cent.
,,	D	$\chi^2 = 11{\cdot}9$	,, ,, ,, 2 ,, ,,

and for the living circumstances curve of Fig. 6:

Married:	own home	$\chi^2 = 2{\cdot}1$	4 d.f.	Not significant.
Single:	parents	$\chi^2 = 4{\cdot}4$	,,	,, ,,
Single:	hostels	$\chi^2 = 6{\cdot}3$	,,	,, ,,
Married:	hostels	$\chi^2 = 25{\cdot}4$	,,	Very significant.

It will be noticed that in the instances where the fit is poor the first point at one month's length of service is high. This tendency has been observed on several curves.

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(ii) *Stability Curves*

No satisfactory method has yet been found for testing stability curves. The average mannings always feature in any calculated statistic measuring goodness of fit and it seems that their variances or some other figures assessing their unreliability should certainly be incorporated in any rigorous significance test. If, however, it is assumed that the average mannings are given constants the χ^2 test may be applied in a manner similar to that for survival curves, and the results of this procedure are perhaps of interest.

The method for comparing groups is to calculate expected numbers of leavers by dividing the total leavers in any length of service category into the ratio of the average mannings in that category. Again considering branch data (Fig. 2), this time with length of service categories defined by 1, 2, 5, 10, 15 and 20 years:

Between B and C	$\chi^2 = 19{\cdot}7$	7 d.f.	Significant at 1 per cent.
,, B and D	$\chi^2 = 13{\cdot}3$	,,	Not significant.
,, A and C	$\chi^2 = 49{\cdot}2$	,,	Very significant.

For the two departments at Branch A using length of service categories defined by 3 months, 1 and 5 years:

Between A1 and A2 $\chi^2 = 21{\cdot}5$ 4 d.f. Very significant.

In order to derive an expected number of leavers for testing the line fit the reverse of the calculation illustrated in Table 1 is employed. Turnover is obtained by working backwards from values of $\varphi(x)$ estimated from the line and multiplied by the average manning. The results for the four branches using the original length of service categories are:

Branch A	$\chi^2 = 33{\cdot}8$	7 d.f.	Very significant.
,, B	$\chi^2 = 14{\cdot}7$	,,	Significant at 5 per cent.
,, C	$\chi^2 = 15{\cdot}0$	,,	,, ,, 5 ,, ,,
,, D	$\chi^2 = 5{\cdot}5$	,,	Not significant.

These results suggest that the line fit is statistically poor but, as has already been mentioned, the estimates of the manning in the low length of service groups are not very satisfactory. The only available data are the mannings on two occasions during the year and they are inadequate when the entrants arrive irregularly. Hence the evidence cannot be regarded as conclusive and the question of the goodness of fit of the lines on stability curves cannot be answered properly until reliable manning estimates are obtained or a better test devised.

It is of interest to amalgamate the first four length-of-service group, sthus obtaining an initial group 0–1 year, and recalculate $\varphi(x)$. When this is done the resulting six points fit a line so well that any non-linearity can hardly be detected by eye.

Time Changes

One feature of labour turnover which has been mentioned several times in Section I, and which was there given as a reason for the superiority of the stability curve method, is its relatively rapid rate of change with time. It has been assumed to be unrealistic to suppose that men joining at times which differ by more than about a year share the same probability of leaving function.

Although a critical presentation of results is really outside the scope of this paper it is of interest to examine briefly this particular point. The data in the tables cover only the year 1951/52 but some data for 1952/53 are also available. They will not be given in detail, but stability curves have been derived in the same way as in Table 1 and the two years compared for each branch by the χ^2 method which has just been discussed. With the first four length-of-service groups combined (i.e. with an initial group 0–1 year) the points again fit the lines nearly perfectly. The values of χ^2 for the comparison of years are:

Branch A	$\chi^2 = 12{\cdot}4$	7 d.f.	Not significant.
,, B	$\chi^2 = 14{\cdot}6$	,,	Significant at 5 per cent.
,, C	$\chi^2 = 32{\cdot}2$	,,	Very significant.
,, D	$\chi^2 = 19{\cdot}8$	,,	Significant at 1 per cent.

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Since the χ^2 test is not really satisfactory these results cannot be claimed to prove anything, but it is probably fair to say that they indicate a real change at least at one of the branches.

Conclusion

This paper has outlined two alternative approaches to labour turnover analyses, both of which are directed towards obtaining the probability of leaving functions for groups of men. One, known as the survival curve method, involves the following through of a sample of engagements and calculating the proportions of men still in service after successive time intervals. The other, using census data, yields what has been termed a stability curve.

It has been found that both the stability and survival curves are approximately log-normal, and this fact has been of great value in the estimation of an expectation of service. This service expectation, it is suggested, is the best single measure of the stability of a group of men which has, so far, been proposed.

Initially it may be thought that the log-normal approximation would be better for a survival curve than for a stability curve which is constructed from several groups of men engaged over a period of 20 years. Such, however, has not been found to be the case in practice, the points about the latter curves being, in general, perhaps a better fit than those for survival curves. This result suggests perhaps that there has been little change in the inherent leaving characteristics of men over the past 20 years, and that factors external to the man himself have had a predominant effect upon his stability.

The methods which have been discussed should prove powerful tools for a detailed analysis of labour turnover and the relative importance of the factors which affect it. From the experience so far gained in their application it seems that a length-of-service grouping defined by the limits 0, 1, 3, 6 and 12 months, 2, 5, 10, 15 and 20 years is more satisfactory than that which was originally adopted for the construction of stability curves. It is this grouping which will be used in the future census returns at The United Steel Companies Ltd. It has also been found that the manning in the first four groups is fairly critical, so that these are now to be taken once a quarter instead of once a year.

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References

Greenwood, M. & Smith, M. (1936) *Sickness Absence and Labour Wastage*, Part II. Industrial Health Research Board Report No. 75. London: H.M.S.O.

Personnel Management Series 1, *Labour Turnover*. London: The British Institute of Management.

Rice, A. K., Hill, J. M. M. & Trist, E. L. (1950), "The Representation of Labour Turnover as a Social Process", *Human Relations*, 3, No. 4.

Discussion on Paper by K. F. Lane and J. E. Andrew

Mr. B. Benjamin: Labour turnover is a matter of such importance in industry that considerable thought must be given to its measurement. While the ultimate aim of management policy is to increase stability to the maximum level no policy can be developed without prior knowledge of the nature of the problem in quantity as well as quality. It is, therefore, timely that this subject should be brought to discussion by the Society. The importance of labour turnover, as indicated by the authors, arises primarily from the cost of obtaining and training replacements for the staff who leave and from the cost represented by the loss of productivity during transitional training periods before the newcomers reach their full level of output. There are, of course, secondary but still important considerations. The organization of staff administration, and the application of welfare services, including pension schemes, is rendered much more difficult when there is a rapid turnover of staff.

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This subject is of threefold interest to me personally. First, because the problem is essentially an actuarial one or at least a problem commonly occurring in actuarial experience; second, because I have recently engaged with others in a study of the impact on our economy of the growing volume of pension rights accorded to the population (Bacon, F. W., Elphinstone, M. D. W., and Benjamin, B., (1954), *J. Inst. Actu.*, **80**, 141) and the subsidiary effects upon mobility of staff have interested me; third, as a taxpayer I am interested in any endeavour to raise the productivity of this country. The problem is one of determining the risk of an employee of particular entry characteristics leaving in a particular interval of time in the future. Essentially, what the authors are trying to do in order to solve this problem is to construct what the actuary calls a service table. Such tables show for a fixed original number of entrants the number of employees remaining at the end of consecutive intervals of time and the number leaving within each interval, in the same way that life tables show the number alive at any age and the number dying between successive ages. It is common for such a table to be elaborated in order to indicate more than one decrement to a particular class of employee. For example, it may subdivide the exits according to reasons for leaving, separating sickness retirements from those due to the attainment of some fixed range of retiring ages and distinguishing resignations or dismissals. The table may also show numbers promoted to a higher level in the service and, therefore, leaving the class of employee to which the service table applies. In this form the table is not only useful for staff administration purposes and in particular for the valuation of pension funds, but it may be used to estimate the optimum intake into various grades of the service in order to ensure the provision of adequate career prospects. This latter objective has become more important in recent years, particularly in large services and in the Armed Forces. The method has already been described by Jones (*J. Inst. Actu., Stud. Soc.* **8**, 49, (1948)). The service table is normally calculated by orthodox actuarial methods in which the risk of a particular movement is calculated by relating the numbers of such movements to a summation of the exact periods of risk of the individuals amongst whom such movements occurred—or an approximation thereto. The methodology forms the subject of some very practical papers in the *Journal of the Institute of Actuaries* in the early part of this century. It is possible to construct the service table by normal methods form the information given in Table I of the paper although the numbers at risk are not given in the refined form which would be desirable. A rough calculation using the values of δ_r as central leaving rates over the specified intervals yields percentages remaining at the end of certain intervals as follows:

Branch A

Time	*Authors' Methods*		*Actuarial Method*
	Engagement	*Census*	
3 months . . .	64·5	65·3	64·8
6 do . . .	52·2	53·0	52·6
9 do . . .	46·5	48·6	48·3
12 do . . .	42·6	45·4	44·7
2 years . . .	38·8	38·1	37·5
5 years . . .		24·9	24·3
10 years . . .		17·4	16·9

This is a fairly close agreement considering the rough use of the data.

That the rates of movement involved in a service table are dependent upon length of service is a feature commonly recognized in the construction of service tables and does not constitute a new problem. We have, therefore, to consider whether the somewhat unorthodox methods used by the authors are justifiable on any other grounds and in particular whether the single figure index used to describe the characteristics of the service table, i.e. expectation of service, is the best one to use.

Here I think we might make some analogy with general vital statistics. It is not usual to rely upon the crude death-rate, that is the simple ratio of total deaths to total population, to describe the mortality of a particular country, or to compare that country's mortality with that of another country, because abnormalities in the sex and age structure of the populations may seriously distort such crude death-rates. If for some reason a population is suddenly depleted of its old people, without there being any change in mortality risks age for age, the crude death-rate will necessarily fall because the reduction in the enumerator will far outweigh the reduction in the denominator. It is not difficult to construct examples of two populations A and B such that mortality of A is heavier age for age than that of B, but because A has a young age structure the crude death-rate is nevertheless not materially higher in A than in B. The following is an example:

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Age	Area A: Population (Thousands)	Area A: Deaths	Area A: Death-rate per 1,000	Area B: Population (Thousands)	Area B: Deaths	Area B: Death-rate per 1,000
0– 4	280	1,400	5·00	220	2,200	10·00
5–24	900	900	1·00	810	1,215	1·50
25–44	910	2,730	3·00	900	2,970	3·30
45–64	720	14,400	20·00	780	11,700	15·00
65–	310	38,750	125·00	350	38,500	110·00
All ages	3,120	58,180	18·65	3,060	56,585	18·49

The standardized mortality rates (England and Wales 1931 population) are, per 1,000—15·3 for Area A and 13·9 for Area B. At young ages the age specific death-rates are lower in Area A than in B, but at the older ages the reverse is true. It is at the older ages that deaths are heavily concentrated and because of the heavy weight of such deaths the age standardized death-rate of A is, as expected, much higher than that of B. The crude death-rates do not differ by much however because the age structure of B is so much older than that of A that it produces an elevation of the crude death-rate to compensate for the lighter age specific mortality rates. The vital statisticians recognize this difficulty and their answer is not to use the expectation of life as a means of summarizing the life table but to concentrate attention upon age mortality rates. If a single figure index is necessary they calculate an age standardized mortality rate, i.e., an average mortality rate in which age specific mortality rates are combined in proportion to weights yielded by a standard population structure. In the example quoted above, the standardized mortality rates do reflect the relative levels of mortality reasonably well. [It must however be admitted that the expectation of life is an age standardized index too.] The crude death-rate is an average in which the weights are taken from the local populations themselves as distinct from a standard population. Standardization, therefore, represents an effective way of avoiding distortion due to unusual population structure. In the same way one would have thought that standardization would be the best way of making comparisons of labour turnover rates between departments or establishments where big differences exist in the employee structure particularly in relation to the characteristics which matter, such as age and length of service. It would seem to me, merely on arithmetical grounds, to represent the simpler solution. The authors may answer that it is difficult to find a suitable standard population.

The authors have adopted a method which although less simple has the merit of describing mathematically the conditions of the system under observation and the possibility of an approach to equilibrium. This also has the advantage of emphasizing the main characteristics of the distributions involved. It is of interest to note that essentially the method described is analogous to the well known actuarial relationship between the force of mortality and the logarithm of the probability of survival. A method of constructing a life table by the use of this relationship was in fact described in 1914 in an Editorial Note which accompanied the publication of King's classic paper on a short method of constructing an abridged mortality table (*J. Inst. Actu.*, **48**, 294 (1914)). In this method values of $\log_5 p_x$ are tabulated by the relationship

$$\log_{e^5} p_x = -m^{(\frac{1}{2})}\left[1 + \frac{m_5^{(\frac{1}{2})} - m_{-5}^{(\frac{1}{2})}}{24}\right]$$

where m is equivalent to the authors δ_r. The expectation of life is then tabulated by a continued formula involving only ${}_5p_x$.

$$\log \tfrac{1}{5}e^{(\frac{1}{2})} = \log_5 p + \log\left[1 + \tfrac{1}{5}e_{-5}^{(\frac{1}{2})}\right]$$

Oddly enough the same number of the journal contains a paper on the valuation of benefits dependent upon promotion to a higher status. (Thomas, E. C. (1914) *J. Inst. Actu.*, **48**, 217).

So far as the calculation of service table functions are concerned, there seems no special merit in the mode of calculation proposed by the authors, and following through their mathematical development gives the impression that although the results obtained are reasonable, the assumptions made at certain points are somewhat strained. One has to remember, too, that for pension fund purposes other functions related more directly to leaving rates are required. It might, therefore, be better to construct the whole service table on this basis. Most actuaries would prefer to work with such rates because they are close to the data, and they think they know how the rates behave much better than they understand the behaviour of more complicated functions.

As to whether the survival and stability curves generated by the authors' method have such an advantage in presentation as to justify the method I am not competent to judge. I would think,

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however, that the primary object of the exercise is to enable those concerned with staff administration to decide whether there is any abnormality in the leaving structure which can be remedied by alteration in the staff administration policy, and this abnormality ought therefore to be shown in such a way that it directly points to the change in policy which should be made. From this point of view it would seem that the stability curves are useful for illustrative purposes but that in the last resort the rates of withdrawal themselves provide a more specific guide to action. I must, however, leave those more directly concerned with staff administration who may follow me to give more authoritative opinions.

I would like to have seen the authors deal more with the question of selection at entry. It is the entry conditions which may have a very important bearing on the leaving structure of the labour force. The object is surely not only to keep the employees when you have them but to choose those at the outset who are more likely to stay, and the analysis of labour turnover should be directed to elucidate those criteria which should be applied in selecting employees in order to achieve stability.

I have done my best, as tradition demands, to be as critical as possible. Notwithstanding criticism of methods, however, I have found this paper interesting and stimulating. It is clear that much remains to be studied and that the final answers are not yet known. The authors recognise this themselves. Only continued experimentation and the type of boldness exhibited by the authors will yield results of practical value to managements. It is our role here tonight to foster and encourage this experimentation. I have very real pleasure in moving a vote of thanks to the authors.

Mr. SPRATLING (in seconding the vote of thanks): Labour turnover is indeed a problem in these days. It would be disastrous for the economy if people became so locked in their jobs that there was virtually no avoidable labour turnover, but labour turnover at too high a level is a source of waste and inefficiency.

Mr. Benjamin is right in assuming that it is important not merely to determine the incidence of turnover but to try to measure the effect of some of the forces which cause it, for management must be concerned to reduce labour turnover by removing or mitigating any identifiable causes of wastage which are partly or wholly within managerial control. The problems of analysis are real. Although much work has been done in recent years on this subject there are as yet no commonly accepted techniques. Many of us are still groping, and it is all to the good that papers such as this should be subjected to the rigours of free discussion.

First, one must be clear as to the type of turnover one is considering. The authors refer to "leavers", and I am in some doubt as to the precise meaning of the term. May I list the causes of wastage and comment briefly on them? Age retirement is foreseeable. Ill-health retirement, death while actively employed, and transfer to other work for medical reasons are relatively unimportant statistically, and foreseeable within fairly narrow limits. Promotion is collectively predictable, but within wider limits and with rather more difficulty. Dismissals are rare when the level of employment is running high. Resignations form by far the most numerous and variable element. This voluntary termination of employment demands investigation and analysis; for analytical purposes, resignations should be separated from the other types of labour wastage.

The crude resignation rate has received wide publicity lately. I do not think that the crude rate is wholly to be despised if used with caution. It can provide a basis for drawing conclusions, but only broad conclusions. If, for example, consecutive values are calculated and used as a time series they will give a fairly reliable indication of trend. The crude rate will often reflect the correlation between the wage rate or earnings for a particular job and the general level of wages for comparable work. As the general level increases, so does the crude resignation rate unless and until the wage rate for the job is re-adjusted to the general level. But the crude rate can be entirely deceptive.

Turning to the authors' particular approach to the problem of measurement, I agree that length of service is probably the dominant factor in determining the level of wastage in any particular period, and I am glad to see it recognized so clearly. The experience of London Transport shows, however, that it is not invariably true that the probability of leaving diminishes with increasing length of service. To illustrate the point, may I refer to the experience of two large groups of employees—bus conductors and station porters? Both men and women are employed on each of these jobs at rates of pay and conditions of service which, for all practical purposes, are the same for men and for women, although differing between the conductors and the porters. For men conductors, we broke the first two years of service down into the eight successive quarters and calculated the probability of resignation for each quarter separately. We found that in each of several periods of observation the second quarter showed the highest probability of resignation. Thereafter the quarterly probability progressively declined. For men porters, an analysis of the experience of the first year of service showed a progressive rate of resignation from one quarter

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to another, the first being the highest. But when we broke the first year down into the twelve successive monthly intervals and measured the probability of resignation separately for each month, we found that it rose through the first and second months to a maximum in the third, and thereafter declined progressively.

For women conductors and women porters we found a different characteristic which was common to both groups. The probability of resignation during the first year of service, taken as a whole, was repeated almost exactly in the second year, and again in the third; thereafter the yearly probability of resignation diminished. Incidentally the women's resignation rates from both jobs were less than those of their male counterparts.

It would be out of place to attempt to assess here the reasons for these particular features. The point is that in all four groups—men and women conductors and men and women porters—the observed probability of resignation according to length of service did not reduce progressively with increasing length of service.

I have referred to yearly, quarterly, and monthly probabilities. The probability is, in principle, simply the ratio which resignations in a given period bear to the corresponding exposed-to-risk. Sometimes it is more convenient to calculate what actuaries know as the central rate of resignation, which is the ratio of the resignations in a stated period to the mean exposed-to-risk. The technical detail was set out in a paper submitted to the Institute of Actuaries by Mr. Lloyd and myself four years ago (*J. Inst. Actu.*, 77, 196, 1951)). We have found these functions to be the most powerful means of measuring wastage. They have the added virtue of simplicity.

In London Transport we are fortunate in having a central record of staff statistics on punched cards. Every staff movement is reflected by a card movement. Schedules can be built up in considerable detail from tabulations, analysing recruitment and wastage by occupation, degree of skill, age, sex, geographical distribution over the London Transport area, and so on. From such data, the rates of resignation can be calculated for different combinations of the recorded characteristics. In relation to a particular investigation, it is a matter of trial and judgment to determine which particular grouping of data yields the most meaningful results. The results shown by different sets of data are so varied that we have found ourselves discouraged from attempting generalizations. In particular, I feel that the proposed expectation of service would fail, just as the more familiar expectation of life fails, by compressing too much into a single figure. As a matter of arithmetic, widely different experiences can resolve into the same or very similar expectations of service. In my experience the differences, and the reasons for them, are generally of more importance than the similarities of the expectations derived from them. The only generalization of which I feel capable is that the values of resignation rates appear to be specific to occupation and time.

If useful results are to be obtained, the measurement of turnover must be supported by other means. For example, some attempt must be made by more subjective methods to discover why people resign from their jobs. It is not easy to find the reason in individual cases. Interviews must be conducted carefully by experienced people, and even then the results yielded by analysis of the data must be viewed with caution.

When all is said and done, industry sees only one side of this matter. A large proportion of the turnover of labour may be due to a small proportion of labour going frequently from one job to another. The individual employer catches a glimpse of these industrial nomads as they come and go from his service. The records of the Ministry of Labour must contain much useful information on this matter, and it might be valuable if research could be done on Ministry of Labour data from this point of view and correlated with the experience of industry itself.

There is still much to be learned. Papers such as this provoke thought and stimulate discussion, and I most cordially second the vote of thanks to the authors.

The vote of thanks was put to the meeting and carried unanimously.

Mr. J. AITCHISON: I have been particularly interested in the application of the log-normal distribution in a new setting. It is not surprising that the log-normal distribution should occur in this context for we have from the authors' own lips that an employee's probability of leaving diminishes with increasing length of service. It is but a short step forward to suppose that Kapteyn's law of proportionate effect holds, namely that the chance of an employee with x years service remaining in service for another y years depends only on the ratio y/x; such a system if allowed to operate freely would generate a stable lognormal population of lengths of service and this is roughly what we are observing in the stability curve approach.

The remainder of my remarks are confined to statistical methodology. In the engagement data method the authors have found a definite curvature in the data as portrayed on logarithmic probability paper in Fig. 3*a*. This is consistent with not x itself, but a simple displacement of it, say $x - \theta$, being log-normally distributed. If θ is taken to be half a month the curvature is

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appreciably reduced. This would seem to be a fairly realistic assumption, for an employee must have some time to find out that he dislikes or is unfitted for his work and he then has to give or be given notice. The same feature does not appear in the census data method, probably because there is a certain averaging out of the data in the derivation of $\varphi(x)$.

While the graphical method of estimation is a most useful one and should always precede any more detailed analysis, there are several points about it which are worth noting. My colleague Mr. J. A. C. Brown and I have recently carried out a study of the graphical method in connection with our own work on the lognormal distribution. We constructed 65 artificial samples with known parameters m and σ and invited a number of associates to plot the points on logarithmic probability paper and estimate the parameters. Our findings are that the reliability of the method falls as the value of σ increases. Now the values of σ in this paper are rather large (among the largest we have met) and although the authors must have gained considerable experience with their vast amount of data, I recommend them to try an equally simple method whose usefulness does not seem to be generally realized. This is the method of quantiles which equates the sample quantiles of order q_1 and q_2 (say) to their theoretical values $e^{m+\nu_1\sigma}$ and $e^{m+\nu_2\sigma}$ where ν_1 and ν_2 are the $N(0, 1)$ quantiles of order q_1 and q_2. One great advantage of this method over the graphical method is that we can obtain some idea of the accuracy of the estimates. It can be shown that the method is most efficient (as compared with the much more laborious maximum likelihood method) when symmetrically placed quantiles are used, viz. at 27 per cent. and 73 per cent. for m, and at 7 per cent. and 93 per cent. for σ; the corresponding efficiencies (which are independent of σ) are 73 per cent. and 65 per cent.

My remarks on estimation apply equally well to the census method. This method may also be thought of as a conditional probit analysis: an employee, having reached a given length of service, is subjected to a further dose of service and reacts by leaving or remaining. For Branches A, B, C and D the lines in Fig. 2 are roughly parallel and it may be that a useful procedure would be an adaptation of the parallel probit method, comparison of the branches being confined to the parameter m.

I was glad to find use being made of a much neglected but often useful property of the log-normal distribution in the derivation of the formula for s_r. This is the property of the moment distribution which in its general form may be stated: the jth moment distribution of a lognormal distribution with parameters m and σ is also lognormal with parameters $m + j\sigma^2$ and σ.

While I agree with the authors that if a single measure of stability is required the expectation of service seems the most natural one, I hope that their work will impress the need for quoting full information on the probability curve, in the form of m and σ or equivalent measures. Then we may apply the results to obtain $F(x, t)$ and $L(x, t)$ for different manning structures, which must be the true aim of such analyses.

Mr. H. Silcock: To one who is interested in problems associated with the industrial labour force, but has not the advantage of familiarity with the excellent work of the actuaries to which previous speakers have drawn attention, it is a pleasure to read a paper in which the authors are at pains to show how misleading crude rates of labour turnover can be. I congratulate them for drawing attention to a specific instance in which reliance on crude rates would lead one to suppose that wastage in A is running at a higher rate than in B when in fact the opposite is true. Hitherto I have had to use hypothetical figures to demonstrate this possibility.

May I confess to some slight disappointment with the stated purpose of the analysis. From the introduction I learn that it is to paint a picture. While I would not underrate the value of an accurate picture, I would like a little more. On p. 309 the authors suggest that there exist intrinsic differences between men. If this is true, and I believe it is, it leads at once to the problem of discrimination between applicants for employment whenever the responsible officer has a choice. I suspect, too, that these intrinsic differences embrace more than age, family circumstances, and place of residence as suggested in the paper. With this in mind I should like to suggest that an analysis of the wastage process should look forward to the time when discrimination may become feasible by linking it with some hypothesis about these differences between men. The authors make the assumption that *similar* men joining within a short period of time may be regarded as a homogeneous group. This seems to me emintnely reasonable provided we emphasize the word *similar*. But if it is to be broadened to include *all* men joining within a short period of time, then it seems to become much less reasonable.

My next point concerns the statement on p. 299 that leaving rates can "vary up and down comparatively widely and rapidly". This notion has been stated so often in the literature that it has become almost an article of faith. Yet nowhere have I been able to find adequate evidence to support it. It is true that crude rates of turnover may exhibit wide variation, but this seems to me quite compatible with relative stability in rates specific by length of service. The statement I have quoted leads us to expect somewhat wide variation from year to year, yet in their examina-

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tion of data they suggest that very little variation, if any, had taken place between 1950–51 and 1951–52. Later, when considering expectation of service, they appear to make use of the hypothesis of no variation to verify that the two methods of approach—the engagement data and the census data—lead to substantially the same result. Later still, in a specific note on the subject at the end of the paper, they suggest that by 1952–53 some change may have taken place in at least one branch. The evidence in the paper does not therefore seem to support the assertion that rates fluctuate widely and rapidly. Perhaps the authors will, at some future date, provide further evidence on the subject.

May I raise one final point on the question of comparability of expectation of service. I would agree that the proposed statistic is comparable over time within the same Department. But if it is used to compare two Departments with rather wide differences in the proportions of skilled, semi-skilled, and unskilled labour, would the authors still regard the comparison as a useful guide to management?

Mr. A. J. H. Morrell: I congratulate the authors not only on the paper itself but on having such admirable data available to them. I was much interested in their remark about the independence or otherwise of the probability-of-leaving function with time. This seems to be a highly controversial matter. The line usually taken is that the probability-of-leaving functions and the survival curves are purely functions of length of service, and Mr. Silcock, I believe, supports that view. It seems to me probable, from investigations in my own company, that the probability-of-leaving function does in fact depend on time, but not so much on the time of engagement as on the time of leaving. I do not see why it should be different for groups of workers taken on at different times when economic conditions are similar, but I should expect a sudden economic crisis to have an immediate effect on the tendency of workers to leave, whatever their period of service. In fact, our own investigation suggests that in times of recession the turnover rate at any length of service falls immediately.

The authors have dealt chiefly with the problem of measuring labour turnover, but the chief problem is that of reducing it. It is important to find out why men leave, and the authors have referred briefly to causes of leaving, which they have summarized as "own request", "ill-health", and what we might call "dismissal". In our own investigation we took the categories of ill-health, domestic reasons (which means housing shortage, transport difficulties, and so on), dissatisfaction or other job, and dismissals, excluding dismissals on account of redundancy. But it is evident that the real reason is often concealed, and men will give ill-health or transport difficulties as their reason for leaving when in fact they have taken a dislike to the foreman.

I was glad that Mr. Benjamin emphasized the importance of adequate selection methods. There is a school of thought, to which Rice and his colleagues belong, which takes the line that because the survival curve is fairly smooth and can be reasonably well fitted by a mathematical law, one can do little or nothing to improve the turnover rate, which seems to me a *non-sequitur* and completely defeatist. If we may take an analogy from a similar field, at any particular time the rate of adult mortality as a function of age can be fitted very well by a formula known to actuaries as Makeham's Law, but we also know that the rates of mortality are gradually falling. Similarly it may be possible to "stretch out" the survival curve.

Finally, on the question of female labour turnover, we have compared female turnover with male turnover and have found much less variation between individual works for females than for males. Generally the rates for female turnover are much higher, particularly for domestic reasons, and the suggestion is that on the whole female turnover is less controllable than male turnover.

Mr. F. J. Lloyd: From my experience at London Transport I agree with the authors that the data must be collected and arranged so that homogeneous groups may be examined. I agree also that length of service is an important factor, but I would suggest that another factor is equally important. This second factor, which is mentioned by the authors, is the effect of time, or the secular effect. This is where I cross swords with Mr. Silcock. The authors mention seasonal trends within a calendar year, but I would stress the importance of the secular trend from calendar year to calendar year and the necessity to allow for this trend in the method of analysis. I regard this trend as measuring the relationship between all conditions of service (including pay) particular to the group under observation and all conditions of service applicable to other industries; the authors refer to general economic conditions.

For example, in three recent consecutive calendar years for a very large and homogeneous group of men the overall crude percentage resignation rates were 3 per cent., 5 per cent., and 9 per cent. During this period all internal conditions of service, with the one exception of wages, remained the same for this group. Resignation rates were calculated for each calendar year of experience subdivided into each year of duration of service during that year of experience. The formulae for calculating these rates are set out in the paper to the Institute of Actuaries mentioned

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by Mr. Spratling. The formulae are of the census type, and it was found that the exposed-to-risk could not be taken, as the authors have taken it, as the mean of those in force at the start and end of the year. This approximation would have assumed that the entry dates were evenly spread over the year, and that the instantaneous rate of resignation over the year was constant. An appropriate adjustment was made to the exposed-to-risk. The resignation rates for the first three years of duration were:

Percentage of men resigning within the year according to length of service

Duration of Service	*Calendar Year* No. 1	*Calendar Year* No. 2	*Calendar Year* No. 3
First year	12	18	31
Second year	5	14	22
Third year	4	7	17
Overall percentage . . .	3	5	9

This table shows that for each calendar year of experience the rates decreased with the length of service. It also shows that during each successive calendar year the overall resignation rate and the resignation rates for each year of duration of service increased. In other words, the increase due to general economic conditions occurred at all durations of service.

One of the methods of analysis suggested by the authors takes a group of men who enter during a particular calendar year and traces their future experience and so calculates survival rates for different durations of service. This is sometimes called a generation or cohort method. They do explain that this method may be somewhat cumbersome, as the history of many batches should be traced. I suggest that unless many batches are traced this method makes no allowance for time or secular changes. For example, on the figures I have given the resignation rate applicable to men within their first year of service in calendar year 1 was 12 per cent. This group of men became the second year men in calendar year 2, and their resignation rate was 14 per cent. They then became third year men in calendar year 3 and the resignation rate rose to 17 per cent. In this example the secular effect was large, but it demonstrates that such a method of analysis may mask the true effect of length of service on the rate of resignation.

I suggest, therefore, that the method which the authors call the "census method", and which I would generalize to cover any method relating the resignation rates precisely to the calendar year of experience, is a sounder method of analysing resignation rates and measuring the effect of length of service.

The authors subsequently replied in writing as follows:

Before replying to the individual contributions to the discussion, we should like to make one general observation which answers those who expressed disappointment about the many aspects of labour turnover inadequately illustrated by results. The scope of the paper was deliberately restricted to its title and the examples were meant primarily to show applications of the method of analysis. They were not comprehensive and formed only a small sample from a large number of results which may be published later.

We realized that the problem was actuarial in character and were therefore pleased to hear the opinions of the several actuaries who contributed. Our purpose in giving a mathematical sketch of the leaving structure of a group was to be clear about the assumptions being made in deriving survival and stability curves. It leads to formulae which, to judge from Mr. Benjamin's first table, give figures differing little from those obtained by standard actuarial methods. Indeed, considering the nature of the data, it is doubtful if any refinements are warranted.

Mr. Benjamin proposes, as an alternative to expectation of service as a single figure index, a length of service standardized turnover rate. Since both are independent of the length of service distribution in the population, the choice between them is not particularly important, but the virtue of the former is that it does not involve any artificial standard. A standard could easily be constructed, but the difficulty would be in getting it generally accepted so that figures from different sources were comparable.

In discussing survival and stability curves Mr. Benjamin seems to have mistaken their purpose. They are not intended primarily for illustrations or presentation to management. They are the

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means which enable conclusions to be drawn from the data, and it is this set of conclusions which goes to the management. For instance, it might emerge that conditions in a particular department were bad or that a bus service to a distant area was a better proposition than the provision of a hostel.

In reply to Mr. Spratling, we have taken all adult male weekly wage earners who left the branch at which they were employed as leavers for the census method of analysis. Own request resignations from the Company comprised 67 per cent. of the total number of leavers, and ill-health resignations—which showed a suspiciously high correlation with the own request leaving rate—a further 9 per cent. Between-department transfers were not considered as leavers in the work, and losses due to promotion to staff and gains from age transfers to adult males were also omitted.

We agree that the crude resignation rate is probably better than no figure at all, but consider that it may be dangerous even to draw broad conclusions from consecutive values used as a time series as Mr. Spratling suggests. For instance, the annual turnover rates in the past three years for branch B of the United Steel Companies Ltd., were 9·8 per cent., 15·3 per cent. and 11·5 per cent. for 1951–52, 1952–53 and 1953–54 respectively. These would suggest that there was a major drop in stability from the first to the second year, followed by a substantial recovery, but the corresponding expectations of service—12·0, 9·4 and 9·4 years—indicate a smaller drop in stability and no recovery. The high turnover rate in the central period was, in fact, mainly attributable to an increase in the engagement rate necessitated by a reversion to 2-shift working in one of the departments, and the alteration to a 44-hour working week.

Mr. Spratling has provided interesting information on the change in the probability of leaving with increasing length of service, showing that it does not necessarily progressively decrease from entry. We realized that such an effect may exist, and the fitting of a log-normal distribution does, in fact, mean that the probability rises initially before diminishing. Usually, however, with the tendency to high turnover rates now existing, the probability reaches a maximum at such an early length of service—a matter of a few days—that it is difficult to detect in the data.

We would agree with Mr. Spratling that very similar expectations of service can be obtained from dissimilar distributions, but maintain that if a single measure of stability is demanded then the service expectation is perhaps the best. As Mr. Aitchison has pointed out, however, any such single figure should preferably be supported by the curve from which it is derived or by the values of m and σ.

We should like to thank Mr. Aitchison for the several constructive comments which he makes. We were sceptical about the efficiency of finding the log-normal parameters by a graphical process and were therefore interested to learn of his experiments. The method of quantiles, which he suggests, would certainly seem to be the best alternative.

As Mr. Silcock has pointed out, stability over the period for which we have collected data did not fluctuate widely owing, probably, to fairly stable economic conditions. Nevertheless, even the variations observed so far are higher than would be experienced in mortality rates, with which we were contrasting leaving rates, and Mr. Lloyd has provided good evidence of the extent to which the latter can vary in a short period of time.

Regarding the comparison of two departments with differing proportions of skilled to less skilled men, it would clearly be fallacious to make no allowance for this in assessing relative stability. It should be ascertained, as far as the available data permit, that the only difference between the groups considered lies in the variable under examination, this being applicable whatever measure of stability is used.

Mr. Morrell makes the point that a sudden economic crisis is likely to have an immediate effect on turnover throughout all lengths of service. With this we agree. It does not, though, conflict with the hypothesis that similar men joining at much the same time share the same probability of leaving function. The graph may have a kink in it but the kink is in the same place for every man. Such a crisis would, in fact, show the essential difference between survival and stability curves. The former would show an abrupt change, whereas the latter would probably remain smooth although different before and after the event.

We are grateful to Mr. Lloyd for presenting such interesting data on the wide and rapid fluctuations that can occur in leaving rates with time. This example is a good illustration of the main disadvantage inherent in the survival curve method of analysis, and we agree with his suggestion that a census type of method, where the leaving rates are estimated over the same short period of time for all length of service groups, is to be preferred.

We are also interested to see that in calculating the exposed-to-risk Mr. Lloyd found that the mean of the manning at the start and end of the year considered could not be justified owing to an irregular engagement rate. This is also true of our data—e.g. the manning in the 0–3 and 3–6 months length of service groups in Table I—and to obtain better estimates of our average labour force in these early groups, we are now collecting the manning data in the first four groups once a quarter.

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As a result of the ballot taken during the meeting, the candidates named below were elected Fellows of the Society:

David John Bartholomew.
Maurice Riley Bone.
Nazhat Chalak.
John Derek Chynoweth.
Keith Ernest Reginald Dennis.
Jack Gammon.
Warren Garland Gilchrist.
John Howard Gray.
Lawrence Donald Hardy.
William Hill.
Derek Alan Holland.
Karthigesapillai Kularatnam.
Harold James Montgomery Langshaw.
John Anthony Llewellyn.
James Stiven Lowden.
John Webster Murfin.
Geoffrey Leonard Parsons.
Cecil Scrogg.
Norman Henry Standing.
John Henry Stanton.
Norman Warburton.
John Vernon West.
David James Wheeler.
Michael Sidney Hampden White.
Ivan John Whitting.
Colin John Williams.

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The Statistical Analysis of Congestion

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1. *Introduction*

One common type of investigation undertaken by operational research workers aims at attaining an efficient use of resources by eliminating or reducing congestion. To provide a theoretical background to these practical investigations a good deal of mathematical work has been done predicting theoretically the congestion occurring in certain very simplified systems, which serve as models of the complex situations occurring in the real world. The present paper describes some of this theoretical work in a general and non-mathematical way.

Congestion is usually produced by the combination of three circumstances:

(i) a flow of *customers* requiring service;
(ii) some restriction on the availability of service;
(iii) irregularity in the flow of customers or in the servicing operation or in both.

There are two forms of restriction on service:

(*a*) a restriction on the number of customers that can be served at a time,
(*b*) a restriction that service is only available intermittently.

In many practical cases the restriction is a mixture of the two forms.

The following examples illustrate the generality of the ideas involved. The customers can be people requiring service at a shop, aircraft requiring to take-off or land (Bell, 1949), patients requiring attention by a doctor at an out-patients' clinic (Bailey, 1952), articles passing along a conveyor belt and requiring, say, to be packed in boxes, telephone calls requiring attention by an operator (Fry, 1928), etc. In the simplest form of these examples there is a single stream of customers and only one customer can be served at a time. In more complicated cases there may, for instance, be several servers available simultaneously. Included here are various staffing problems in which, for example, the customers are items of work coming into a testing department and it is required to find how the delays prior to testing depend on the number of workers in the department.

In another important application (Ashcroft, 1950; Benson and Cox, 1951) the customers are machines stopping intermittently and requiring attention by an operative before restarting. Groups of machines under the care of one operative are common; for example in the textile industry, and the practical problem is the determination of the optimum number of machines per operative and, more generally, of the production to be expected with any given operative loading.

In the previous examples the restriction on service is primarily of type (*a*), although the second type can arise if the server or operative has duties in addition to the service of customers. Some traffic problems, on the other hand, involve a restriction primarily of the second type. Thus in queueing for a bus, service may only be available at infrequent intervals although the number of customers served on arrival of a bus may be large. Or again, in turning from a minor road into a major road, service is restricted both by the presence of other customers and by the need to wait until a sufficient gap occurs in the traffic on the major road.

Some more examples are mentioned below, particularly in §5, and others from everyday life and from industry will no doubt occur to the reader.

2. *Two Particular Problems*

The nature of the theoretical analysis of congestion will now be illustrated by considering in some detail two special problems.

Example 1: *Simple queueing.*—Suppose that there is a flow of customers unaffected by the state of the queue, that only one customer can be served at a time, that service takes a certain time called the *service-time*, not necessarily the same for each customer, and that the server is always available for serving customers. All the first set of examples in §1 illustrate this situation: for definiteness I suggest that the reader thinks of a shop queue with a single server.

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Example 2: *Machine-minding*.—The problem was explained briefly in §1. The customers are machines that stop intermittently and require attention before restarting. The server is the operative who can attend to only one machine at a time.

The distinction between Examples 1 and 2 is comparatively subtle and will now be explained. Suppose that at some instant all the machines under the operative's control are stopped. Then there is no possibility of a further machine stopping at that instant, i.e. no further customer can join the queue. Quite generally in Example 2, the chance of a further customer joining the queue at any instant depends on how many customers are already waiting. In fact Example 2 is a special case of a wide class of situations in which the chance of a new customer arriving, and possibly also the service-time, depend on the state of the queue. In Example 1 the arrival of customers is assumed to be unaffected by the state of the queue.

We have in these examples our first two requirements for congestion, the flow of customers and the restriction on their service. What about the third requirement, the existence of irregularity? If in simple queueing the customers present themselves for service at regular intervals and if service always takes the same time, less than the arrival interval, then once any initial queue has dispersed each customer can be served immediately on arrival. But as soon as there is enough irregularity either in the arrival instants or in the service-times or in both, it will from time to time happen that several customers are awaiting service simultaneously and congestion then occurs. Similarly, in Example 2, whenever sufficient irregularity is present, production is lost not only while the machines are being attended to, but also while they are stopped awaiting attention, the operative being engaged on another machine.*

Occasionally the irregularity arises from a complex strictly recurring pattern of events but much more frequently it is haphazard, i.e. statistical, in character. That is why the theoretical study of congestion is a task for the statistician.

Since congestion depends in an essential way on irregularity, any assessment of congestion based purely on average arrival rates and service-times is liable to be very misleading.

If in Example 1 the mean service-time exceeds the mean interval between the arrival of successive customers, the number of customers waiting in the queue will grow indefinitely until some corrective action is taken, such as the provision of extra service facilities, or the cutting off of the flow of customers. While the detection and prevention of such "unstable" situations are of great practical importance, they have not received much attention theoretically; some simple approximate formulae are, however, given in the Appendix to this paper.

By far the most theoretical work has been done on systems in *statistical equilibrium*, i.e. on systems in which the number of customers waiting in the queue oscillates in such a way that its mean and distribution remain constant over a long period. For this it is necessary in Example 1 that the mean service-time shall not exceed the mean interval between successive customers. If the two means are equal, equilibrium will be obtained only in special circumstances.

The first step in the theory is to define dimensionless quantities to measure the average properties of arrivals and service-times. To do this: in Example 1, define the *traffic-intensity* r by

$$r = \frac{\text{mean service-time}}{\text{mean interval between the arrival of successive customers}}.$$

The case $r > 1$ is always unstable.

In Example 2, let

$$p = \frac{\text{mean service-time}}{\text{mean running interval between stops on a single machine}}$$

$$= \text{average amount of time spent by operative to keep a single machine running for unit time.}$$

In Example 1 we may require to know:

(i) the mean queueing-time per customer, i.e. the average time elapsing between the arrival of a customer and the start of his service; the mean time spent in the system is the sum of the mean queueing-time and the mean service-time;
(ii) the mean number of customers in the queue at a time;
(iii) the average rate at which customers pass through the system;
(iv) the proportion of time the server is busy serving customers.

* This loss of production is often said to be due to machine *interference*.

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The quantities (i)–(iv) are averages and in many industrial applications it is these that have a direct economic interpretation. However, there certainly are applications where a knowledge of averages is insufficient. For example, suppose that the customers are batches of material that have completed the first stage of processing and are queueing awaiting the second stage. It may happen that a delay of less than one hour is allowable but that longer delays have a harmful effect. Then the chance that the queueing-time exceeds one hour is of more interest than the mean queueing-time. This aspect is not dealt with in this paper.

There is clearly a close relation between the quantities (i)–(iv); if, say, the average rate of arrival of customers is reduced, all the quantities (i)–(iv) are reduced. As a general rule we require (i) and (ii) low and (iii) and (iv) high, so that a compromise is needed. This is discussed more fully below. Similarly in Example 2 the quantity corresponding to (i) is the mean delay per stop awaiting attention and this determines the rate of production per machine. The quantity corresponding to (iv) is the operative efficiency, i.e. the proportion of time that the operative spends attending the machines and this determines the rate of production per operative. Production per machine is maximized by having a small number of machines per operative while production per operative is maximized with a large number of machines per operative. Again a compromise is necessary.

The object of the theory of congestion is the provision of formulae or numerical tables for predicting (i)–(iv), given the statistical form of the flow of customers and the frequency distribution of service-times. Such a prediction is of little value when we are merely interested in describing a particular situation, since it is usually no more difficult to measure (i)–(iv) than to measure arrival or service-times. However our practical interest is usually in the effect of modifications designed to reduce congestion, and it is often difficult or impossible to find experimentally whether proposed changes are worth while. Thus Murdoch (1952) has described an application where the customers are men requiring to grind their tools at a single grinding machine. It was required to find whether the introduction of a second grinding machine was justified. The frequency with which tools required grinding, the time taken to grind them and the mean queueing-time could all be measured. But the question was: would the extra production resulting from the reduction of queueing-time justify the expense of an additional machine? To answer this rationally it was necessary to estimate the mean queueing-time with two grinding machines and this clearly could not be done experimentally; it had either to be guessed or to be obtained theoretically. This illustrates the main use of the theory; a second use is in the interpretation of data. For example, observations under a range of conditions of the delay to pedestrians crossing a road may taken an added significance when considered in the light of a theory (Tanner, 1951).

The first step in the development is to write down simple equations obtained by considering the definitions of r, p and the quantities (i)–(iv). These are:

Example 1.—The proportion of time the server is engaged is the smaller of r and unity. The rate at which customers pass through the system is the reciprocal of the larger of the mean service-time and the mean interval between the arrival of successive customers.

Example 2.—The rate of production per operative equals operative efficiency divided by p, and the rate of production per machine equals the operative efficiency divided by Np, where N is the number of machines per operative. The operative efficiency is the proportion of time the operative spends restarting machines.

Though mathematically trivial these equations are important. First, they show how to determine r, p experimentally without a direct timing of operations. Tippett's snap-round method (Tippett, 1935) can be used to estimate the proportion of time for which the operative or server is busy and this, combined with a measurement of total production or number of customers served, enables p to be found in Example 2, and r, the mean service-time and the arrival rate in Example 1. If an independent estimate of the stoppage rate is available in Example 2, the mean service-time can be estimated. If the distributions of arrivals and service-times are required, direct measurement will be needed, but even in such cases it is often useful to have an independent check on the mean values. The advantages of avoiding stop-watch timing in this sort of work are well-known.

Second, the equations can sometimes be used directly. For instance in Example 2, if the maximum proportion of time that the operative can spend restarting machines is E, the rate of production is E/p, provided that N and p are large enough to provide sufficient work for the operative. Therefore we can predict immediately the effect on production per operative of a change in p, provided that E is constant. But to find how many machines per operative are

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needed, to find the production per machine and to strike a balance between machine and labour costs, the more sophisticated theory is required.

For the next step in the theory, definite statistical assumptions are introduced. The pattern of instants at which customers arrive is assumed to be of a simple statistical form, usually either a completely random series of events or a completely regular series of events. The service-times are assumed to be random quantities independent of one another and of the state of the queue and having a known frequency distribution. It is then a mathematical problem to work out the quantities (i)–(iv) and for our two examples the most important results are as follows:

Example 1.—When $r < 1$ and the arrivals are random,

$$\text{mean queueing-time/mean service-time} = \frac{r}{2(1-r)}(1 + C_s^2),$$

where C_s is the coefficient of variation of service-time. This is known as Pollaczek's formula (Kendall, 1951). The corresponding result for regular arrivals is expressed by complicated formulae which have not been fully tabulated, although a few numerical results are available (Lindley, 1952 ; Kendall, 1953). Until extensive tables are published the following approximate formulae* may be used:

(i) If r, C_s are sufficiently small to make the following expression less than one-tenth of the mean service-time,

$$\text{mean queueing-time} \simeq \int_0^\infty xf(x+a)\,dx + \int_0^\infty dx \int_0^a f(y+a)f(x-y+a)\,dy,$$

where $f(s)$ is the frequency curve of service-time, and a is the interval between successive arrivals. This can be integrated numerically once the distribution of service-time is given.

(ii) If $r > \frac{1}{2}$ and C_s is large enough for the congestion to be appreciable

$$\frac{\text{mean queueing-time}}{\text{mean service-time}} \simeq \frac{r}{2(1-r)} C_s^2 - 0{\cdot}6\left(r - \frac{1}{10}\right) C_s.$$

Example 2.—The answer is given by published tables showing the operative efficiency, and hence the rate of production, when the stops occur randomly in the running-time of the machine, and when

(i) the service-time is a constant (Ashcroft, 1950);

(ii) the service-time has an exponential frequency distribution (Benson and Cox, 1951; Cox, 1954*b*), i.e. a particular mathematical distribution with a coefficient of variation of 100 per cent.

The operative efficiency for any other distribution of service-times can be obtained quite accurately by interpolating between (i) and (ii) linearly on the square of the coefficient of variation of service-time.

To sum up, these formulae and tables enable the congestion to be predicted from the statistical properties of the flow of customers and of the service-times. Some of the practical implications of the results are discussed in the next section.

3. *Discussion of Solutions*

We discuss in turn a number of detailed points connected with the solutions of the problems of §2; the reader not interested in details should omit this section. The discussion is mainly concerned with simple queueing.

Random variability of service-time.—In simple queueing with random arrivals, the mean queueing-time increases, at first very slowly, with the coefficient of variation, C_s, of service-time. Thus for a fixed mean service-time and arrival rate the mean queueing-time is increased only by 1 per cent. for an increase of C_s from 0 to 10 per cent. and only by 4 per cent. by an increase of C_s to 20 per cent. With regular arrivals, on the other hand, C_s is of great importance. The formulae express quantitatively what is obvious in a general way on common-sense grounds. In Example 2 the effect of changes in the coefficient of variation of service-time is rather small.

* The first of these formulae is obtained by assuming that there is never more than one customer waiting; the second is an empirical equation fitted to published figures.

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In both examples, however, changes in C_s have an appreciable effect on the variability of queueing-time.

The coefficient of variation C_s measures the *random* variation of service-time. Such variation must not be confused with:

(*a*) variation correlated with the state of the queue. Thus a tendency to serve more quickly when there is a large queue reduces the mean queueing-time, and so has the opposite effect from a random variation of service-time;

(*b*) a steady trend in mean service-time, such as a steady increase produced by fatigue. This must be considered as a variation in r and dealt with by the method indicated below.

The traffic-intensity, r.—When arrivals are random and the service-time constant, the ratio of mean queueing-time to mean service-time is $\frac{1}{2}r/(1-r)$ and this gets very large as r approaches unity. The practical implication is that if the mean queueing-time is to be kept small, the average service-time must be appreciably less than the mean interval between customers, i.e. the system must not be loaded to near its apparent "capacity" as determined by average values. The same conclusion follows from the formula for regular arrivals, provided that the service-time is not constant, but in this case the mathematics needs to be interpreted cautiously. The formulae give the queueing-time averaged over a very long period and the reason that this is large for r near unity is that eventually very long queues develop, take a long time to disperse and greatly inflate the mean queueing-time. But if C_s is fairly small, if the initial queue is not large and if the system is only run for a short time, large congestion may have no chance of developing.

Thus Bailey (1952) showed that a suitable appointment system for an out-patients' clinic has $r = 1$ and that the queueing-time averaged over a clinic of 25 patients is quite small, even though the theoretical mean queueing-time for an infinite clinic is infinity. Also in an investigation of the speed of certain conveyor-belt systems, which could be regarded as exemplifying simple queueing with almost regular arrivals, Dr. R. Conrad showed that $r = 1$ was an appropriate traffic intensity. There is some further discussion in the Appendix to this paper.

Regular arrivals.—For a given average arrival rate and a given distribution of service-times, the queueing-time is much less for regular arrivals than for random arrivals. Some approximate figures are given in Table 1.

TABLE 1

Mean Queueing-time/Mean Service-time

Traffic intensity r	$C_s = 0$ *Arrivals*		$C_s = 1/\sqrt{2}$ *Arrivals*		$C_s = 1$ *Arrivals*	
	Regular	*Random*	*Regular*	*Random*	*Regular*	*Random*
0·5	0	0·5	0·1	0·8	0·3	1·0
0·7	0	1·2	0·4	1·8	0·9	2·3
0·9	0	4·5	1·9	6·8	4·2	9·0

If the value of customers' time can be assessed economically it is possible to work out how much it would be worth spending on the introduction of an appointment system.

Variations in r.—Sometimes arrivals are random over fairly long stretches but the average rate changes from period to period, either gradually or suddenly. Or the mean service-time may change in a similar way. Both these possibilities amount to a variation in the traffic intensity r; if the traffic intensity varies slowly over a long time, with mean $\bar{r}$ and standard deviation σ_r, Pollaczek's formula (for random arrivals) may be modified to give*

$$\frac{\text{mean queueing-time}}{\text{mean service-time}} \simeq \frac{\bar{r}}{2(1-\bar{r})}(1+C_s^2)\left(1+\frac{\sigma_r^2}{\bar{r}^2(1-\bar{r})^2}\right).$$

The modifying factor, the last term in brackets, is usually fairly small; for example in the first formula with $\bar{r} = 0{\cdot}6$, $\sigma_r = 0{\cdot}1$, the factor is 1·17 representing a 17 per cent. increase in mean queueing-time. A case that sometimes arises and which is not covered by the above formulae is when there are occasional long stretches with r greater than unity. The use of Pollaczek's formula

* This is obtained by expanding Pollaczek's formula for mean queueing-time in powers of $r - \bar{r}$ and averaging.

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with the average traffic intensity, which may be appreciably less than unity, would considerably underestimate the mean queueing-time, since a very large queue will build up in the period of high traffic intensity and its effect persist into the following periods. An approximate method of investigating this situation is given in the Appendix.

Other arrival patterns.—The above formulae apply to the simplest arrival patterns, the completely random and the completely regular. In Example 2 the numerical conclusions apply reasonably well when the stoppages on individual machines are not random, provided that the number of machines per operative is not very small and that a large proportion of the stoppages are not at regular intervals in running-time. The reason is that with several machines running more or less independently any pattern in the occurrence of stops on individual machines has little effect on the pattern of stops as a whole. With Example 1, on the other hand, the distribution of arrivals is important. Other arrival patterns that can be dealt with are:

(i) "aggregated random" arrivals. There may be a series of *arrival instants* distributed completely randomly, the customers arriving in groups so that at some arrival instants there is one customer, at some two, and so on. Given that "group size" is distributed randomly with a known frequency distribution, it is possible to make the appropriate modification to Pollaczek's formula.

(ii) "general independent" arrivals. The main arrival pattern, apart from the random and the regular, to have been studied mathematically, assumes that the intervals between successive customers are independent random quantities having a known, but arbitrary, frequency distribution. This, while appearing very general mathematically, is of rather limited application because most of the departures from randomness or regularity encountered in practice involve correlation between successive arrival intervals. Two cases to which the method can however be applied are:

(*a*) when customers arrive randomly at a queueing point with several servers and are allocated in strict rotation to the different servers;

(*b*) when the output of one queue forms the input of another and the server of the first queue is never free. In this case the intervals between successive arrivals at the second queue have the same distribution as the service-time in the first queue. If the server in the first queue is frequently free the joint distribution of intervals is complicated. There are many applications where a series of queues is involved but there is little theoretical work on such systems.

Availability of server.—The formulae discussed so far assume that the operative or server is always available for service. Frequently in the machine-minding problem, the operative has duties other than the repair of stopped machines, and also an allowance must be made for relaxation and general supervision. In textile processing, for example, the *ancillary work* includes fetching and carrying bobbins, cleaning and any work at the machines that can be done while they are running. What is needed is a simple way of introducing allowances for ancillary work into the previous solutions. This can be done by making a rather artificial distinction (Benson, 1952; Benson and Cox, 1951; Benson *et al.*, 1953) between:

(*a*) ancillary work that can be fitted into those instants at which all machines are running;

(*b*) ancillary work that is done in frequent short stretches irrespective of the state of the machines;

(*c*) ancillary work that is done in very occasional long stretches.

When the amounts of the various types of ancillary work are specified, the approximate rate of production can be estimated by a simple modification of the previous method. A similar subdivision of the ancillary work would no doubt be useful in other problems.

Balance of requirements between server and customers.—It was pointed out above that there is a contradiction between the requirements that the queueing-time should be low and that the through-put of customers should be high; in Example 2 the contradictory requirements are that production per operative and production per machine should both be high. There are two ways of proceeding if it is desired to attain a balance between these requirements. The first is to express the value of customers' time, of server's time and of the completion of the service of a customer in a common unit, usually of money. The "profit" of the system can then be maximized. The second, and less satisfactory, method is to restrict say the server's idle time to a certain small value and then to minimize the customers' queueing-time.

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Thus in estimating the optimum number of machines, N, per operative in Example 2, one would in principle find for given N the contribution of operative and machine costs to the cost of the final product and hence, knowing the rate of production, the profit for any N can be found, and N chosen to produce a maximum. Although costs may be difficult to determine, there are at any rate some applications where this calculation can be made. But if we try to apply the method, say to the design of hospital appointment systems, it would be necessary to find the ratio, R, of the value of one minute of a doctor's time to the value of one minute of a patient's time and it is doubtful if agreement could be reached on a sensible number* to take for R. It is here that the second method is sometimes useful; suppose that we decide that not more than 1 per cent. of the doctor's time must be spent waiting for a patient and then, subject to this condition, design an appointment system to minimize patients' queueing-time. Of course the choice of the particular figure of 1 per cent. really amounts to a concealed choice of R, but I suspect that in presenting conclusions there is often a psychological advantage in proceeding this way.

Accuracy of estimation.—The theoretical results can sometimes be used to find approximately how accurately service-times, rates of arrival of customers, etc. should be measured (Cox, 1954*b*). It will often be found that most effort needs to be devoted to measuring the rate of occurrence of randomly occurring events, e.g. random machine stoppages.

4. *The Investigation of Congestion*

In a general paper like this it is hardly possible to say much likely to be of immediate practical value in a particular application. It is, however, appropriate to discuss briefly some of the methods available for reducing congestion.

In investigating a complicated system the first step would be to determine the points at which congestion occurs and the nature of the restriction on service, and then to estimate very roughly the rate of arrival of customers and the mean service and queueing-times at each point. From such a preliminary survey the points at which detailed investigation is likely to be most profitable can be found and these examined more thoroughly.

Suppose, therefore, that a single point of congestion has been isolated for study. (In doing this we must not forget that in a complicated system a change in the congestion at one point has its effects at other points. Thus the customers leaving one queue may form all or part of the input of a second queue.) Consider therefore a single simple queue of the type dealt with in §§2, 3 and let us examine methods available for improving the efficiency of the system. In most applications only one or two of these methods will be practicable.

Reduction of service-time or its variation.—The effectiveness of this can be assessed from the formulae given above. Conventional work-study methods would be used to find the best way of reducing or standardizing service-time.

Control of arrival pattern.—The appreciable gains consequent on changing a random arrival pattern into a regular one have been shown in Table 1. One of the main statistical problems connected with appointment systems is: how much of this gain remains if only partial control can be achieved over the arrival of customers? For example, customers may be given appointments at unit time intervals but be unpunctual; if the random variation in the difference between actual arrival time and appointment time is large compared with the unit interval, the appointment system will clearly be ineffective. No mathematical solution is known for predicting the mean queueing-time corresponding to a given random variation of unpunctuality, although the problem has been investigated by sampling experiments.

The conversion of a random input into a regular one is one type of control; another is a general smoothing out of long-term irregularities of arrival rate and, in particular, the avoidance of occasional long sections in which the local traffic intensity exceeds unity.

Combination of several queues.—Suppose that there are several similar queueing systems with different servers dealing independently with distinct sets of customers. Congestion can be greatly reduced by reorganizing the work so that the customers form a single queue, the leading customer moving forward as a server becomes free. The following table (Kendall, 1953) illustrates the gains that can occur when arrivals are random and the service-time exponentially distributed, $C_s = 1$.

* Except possibly among doctors who might agree that $R \simeq \infty$.

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TABLE 2

Properties of Combined Queues

Traffic-intensity of separate queues	*Mean queueing-time/mean service-time*		
	Separate queues	*Two queues combined*	*Three queues combined*
0·5	1·0	0·3	0·2
0·9	9·0	4·3	2·7

There are other, rather less efficient, methods of pooling queues; for example each customer may on arrival be assigned at random to a server or be free to choose his server. In the latter case the natural thing is to go to the server with the smallest number of customers waiting in front of him, but if the dispersion of service-time is high, this procedure will lead to a rather higher mean queueing-time than the method of forming a single queue.

On the other hand the division into separate queues would be justified if, by allowing the servers to specialize, service-times could be reduced. Of course we do not need mathematical calculation to see that the above statements are qualitatively correct; the point of the mathematics is to predict quantitatively what will happen when the system is modified and hence to indicate what lines of investigation are likely to be most profitable. Many of the theoretical problems connected with multiple queues are unsolved; a brief note on methods of solution is given in §5.

An example is the method adopted at main post offices, where instead of having separate counters for each type of business, there are just two broad groups.

Priorities.—So far we have considered the customers to be statistically equivalent. The mean queueing-time is then independent of the order in which the customers are served, although the dispersion of queueing-time and the frequency of long queueing-times are minimized by serving customers in the order of their arrival. If however, the server can estimate beforehand the service-time of each customer, there will be an advantage in serving first those customers with short service-times. Or the value to be placed on different customers' time may be different, in which case the order of serving should depend on this as well as on the service-times.

The simplest case is when there are two types of customer and the server can recognize to which type each customer belongs. The two types have different arrival rates and distributions of service-time. The modification to Pollaczek's equation when customers of one type are given priority has been given by Cobham (1954) and in unpublished work by M. C. Kodikara.

For example in unloading certain types of ship it may be that the larger ships take longer to unload but that the loss due to keeping them waiting is high and that they are given priority. There are several ways in which a system of priorities can enter the machine-minding problem discussed in §2:

(*a*) certain types of stop may take less time to repair than others and be given priority (Benson and Cox, 1951);

(*b*) certain machines may have lower stoppage rates than others and be given priority;

(*c*) when an operative has a "mixed share", different machines may have different stoppage-rates, repair times and running speeds and the value of the product on different machines may be different.

Instead of there being two types of customer it may be possible to estimate, individually for each customer, the service-time, s, and the loss, w, if he is kept waiting unit time. It may also be possible to predict to some extent the future arrival of customers. There is then a range of problems open for investigation concerning the optimum rule of queue-control. The most obvious such rule would be to serve first the customer with the smallest value of sw. Further complications are not difficult to imagine; it may be allowed, at a certain cost, to interrupt the service of a customer to deal with a V.I.P. who has just arrived, the cost of keeping customers waiting may not be proportional to their queueing-time, the arrival-times of the customers may be to some extent controllable, etc.

Arrangement of other duties.—It may sometimes be possible to arrange that additional servers can be called upon either for short periods when the actual congestion is high, or from time to time for longer periods when the rate of arrival of customers is expected to be high. This would depend on supplying the additional servers with other duties that could be interrupted when necessary.

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5. *Available Theoretical Techniques*

It frequently happens, particularly in some of the more complicated problems in §4, that the theoretical analysis of the particular situation of interest is not available in the literature. There are then three ways of proceeding:

(*a*) by mathematics;
(*b*) by sampling experiments;
(*c*) by constructing a special analogue computer.

These will be discussed briefly.

A mathematical solution is by far the most satisfactory if it can be obtained fairly simply, particularly if the behaviour of the system is required for a wide range of conditions and if there are several variable parameters. Unfortunately the only situation that can be tackled in generality is that where all arrival patterns are completely random and all service-time distributions exponential. (For example it is possible under these conditions to deal quite generally with a queue in which arrival rates and service-times depend on the number of customers in the queue (Brockmeyer *et al.*, 1948)). The properties of the system in statistical equilibrium then depend on the solution of a system of simultaneous linear equations (Fry, 1928). The number of equations in the system, one for each distinct configuration, may however be very large, particularly in complicated systems. The restriction to exponential distributions can be relaxed to include a set of distributions related to the exponential (Brockmeyer *et al.*, 1948; Cox, 1954*a*), but the cost is usually a substantial increase in the number of equations. Solutions covering general distributions, such as Pollaczek's equation for the simple queue, are only available in special cases. Another way of reducing the solution to that of a set of simultaneous linear equations is to approximate to the frequency distribution of service-time by a small number of discrete frequencies h apart and to suppose that arrivals can only occur at a discrete set of instants h apart. Other mathematical methods are summarized in Lindley (1952).

To solve a problem by sampling experiments, the service-times and arrival instants of a large number of customers are found by drawing random quantities from the appropriate frequency distributions and the course of the system built up either graphically or arithmetically. The method is of most value where an approximate answer is required quickly for a particular set of conditions. An excellent example of the method is the investigation, already referred to, of waiting at out-patient clinics. The method is flexible in that complicated problems can be tackled, but becomes very laborious if a wide range of parameters (arrival rates, etc.) have to be examined without the aid of high-speed computing machines. Subsidiary, but important, uses of the method are to check that effects thought to be unimportant can be neglected in mathematical work, and to suggest approximations to simplify mathematical calculation.

Examples of special analogue computers are the machine (Wardrop, 1954) constructed at the Road Research Laboratory to examine delays at fixed-time traffic signals and various machines to determine congestion in complicated telephone systems (Kosten *et al.*, 1949). Normally the construction of a special machine is justified only for an extensive investigation.

6. *Further Problems and Summing-up*

There are a number of other situations which, while at first sight not concerned with congestion, are closely connected with the problems we have been considering. For example there is a group of problems to do with the size of stores (Herne and Nickols, 1952; Simaika, 1949; Smith, 1953*a*). In the simplest case material is placed into a store either at a steady rate or in amounts of randomly varying size at intervals that may vary randomly. When the store is full no further material can be added. It is usually required to find the smallest size of store that will ensure that material is nearly always available on demand; more precisely it is required to strike a balance between the cost of providing a large storage space and the loss resulting when material is demanded and the store empty. The connection with the theory of congestion can be seen by considering a store with a steady drain and with material arriving in batches. Think of each batch as a "customer" whose "service" is complete when the batch is fully used (Smith, 1953). Then the storage problem is seen to be equivalent to a queue in which no further customers are admitted when the congestion is high.

Storage problems in which the input is partly controllable and in which it is required to determine a suitable strategy for ordering material, are called problems of *inventory policy* and have

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been extensively studied by American econometricians (Arrow *et al.*, 1951; Laderman *et al.*, 1953). Another group of similar problems is connected with *production planning*. In the simplest form of this a plant can manufacture two products. Demand for the two products is predictable to a certain extent but shows substantial random variation; it is desirable to have long production runs of each product. What strategy should be followed in deciding when to change from one product to another? I have not seen a mathematical discussion of such problems although rule-of-thumb solutions to them are no doubt known to practical men.

A full operational study of any instance of these problems, whether of congestion, storage, etc., from the preliminary survey to the putting into effect of the final recommendations, will involve many difficulties, technological, economic, psychological, and managerial; mathematical and statistical considerations will form but a comparatively small part of the work. Nevertheless I hope it is clear that familiarity with the mathematical theory will be useful, both in leading to quantitative estimates of what will happen when a system is modified, and in giving a general insight into the behaviour of congestion.

Appendix

Theory of a Rush Hour and Related Topics

With a few important exceptions (Kolmogoroff, 1931; Palm, 1943; Smith, 1953*b*; Volberg, 1939) the great majority of theoretical work on congestion has dealt with systems in statistical equilibrium. There do not appear to be available simple formulae for predicting approximately the behaviour of systems not in equilibrium; a few such formulae are given in this Appendix.

Consider a simple queue in which the mean and coefficient of variation of service-time are $\bar{s}$, C_s and in which the mean interval between successive customers is $\bar{a}$ and the variance of the number of customers arriving in time t is $V_a(t)$. For regular arrivals $V_a(t) = 0$ and for random arrivals $V_a(t) = t/\bar{a}$. The traffic intensity is $r = \bar{s}/\bar{a}$.

Now suppose that initially there are n_0 customers awaiting service and that the traffic intensity, r, exceeds unity. The number of customers in the queue will tend to grow; what can we say about $n(t)$, the number waiting at time t? If n_0 is not too small and if r is appreciably greater than unity, we may, to a good approximation, suppose that the server is never free in the period from 0 to t. It can then be shown from two equations in the theory of sequential sampling that the mean and variance of the number of customers served in time t are approximately $t/\bar{s}$ and $C_s^2 t/\bar{s}$*. The number of arrivals has mean $rt/\bar{s}$ and variance $V_a(t)$, so that the mean and variance of $n(t)$ are given by

$$E[n(t)] \simeq n_0 + \frac{t}{\bar{s}}(r-1), \qquad (1)$$

$$V[n(t)] \simeq V_a(t) + \frac{t}{\bar{s}} C_s^2 \qquad (2)$$

If n_0 itself has a distribution, the mean is used in (1) and a term $V(n_0)$ is added to (2).

Consider the queueing-time, $Q(t)$, of a customer joining the queue at time t, assuming that customers are served in order of arrival. It will be the sum of approximately $n(t)$ service-times so that

$$E[Q(t) \mid n(t)] \simeq n(t)\,\bar{s}$$

and

$$V[Q(t) \mid n(t)] \simeq n(t)\, C_s^2\, \bar{s}^2$$

$$E[Q(t)] \simeq n_0\bar{s} + t(r-1) \qquad (3)$$

$$V[Q(t)] = E_{n(t)}\, V[Q(t) \mid n(t)] + V_{n(t)}\, E[Q(t) \mid n(t)]$$
$$\simeq n_0\bar{s}^2 C_s^2 + t\bar{s}rC_s^2 + V_a(t)\,\bar{s}^2 \qquad (4)$$

The expected value of the total queueing-time of all customers joining the queue between 0 and

* For the proof see, in a different connection, Cox and Smith (1954) and other papers cited there.

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T can be found approximately, since the arrival instants are on the average uniformly spread over $(0, T)$ at a density $1/\bar{a} = r/\bar{s}$. Therefore the required quantity is

$$\frac{r}{\bar{s}}\int_0^T E[Q(t)]\,dt = rn_0T + \frac{r(r-1)}{2\bar{s}}T^2. \quad . \quad . \quad . \quad . \quad (5)$$

These formulae, which are related to the results of Volberg (1939), show the rate of growth of a large queue; consider now the converse problem of the time taken for a large queue to disperse, when the traffic intensity is less than unity. Suppose that initially there are a large number n_0 of customers in the queue and that the traffic intensity r is less than unity. We may say rather arbitrarily that the effect of the initial queue has disappeared when the queueing-time of a new customer is first equal to the average queueing-time of the system in equilibrium, $\overline{Q}$, say. It can be shown that if n_0 is large and the arrivals random, the time τ to reach equilibrium is approximately normally distributed with approximate mean and variance given by

$$E(\tau) = (E(n_0)\,\bar{s} - \overline{Q})/(1-r),$$

$$V(\tau) = r\bar{s}(1 + C_s^2)(E(n_0)\,\bar{s} - \overline{Q})(1-r)^{-3} + \bar{s}^2(E(n_0)\,C_s^2 + V(n_0))(1-r)^{-2}. \quad . \quad . \quad . \quad . \quad (7)$$

The expected value of the total queueing-time of the customers joining the queue between 0 and τ is

$$\frac{r}{2(1-r)}[(E(n_0)\bar{s})^2 - \overline{Q}^2]. \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Finally we can, from (1) and (2), estimate the behaviour of a simple queue with $r = 1$; it is known (Lindley, 1952) that in general such a system cannot attain statistical equilibrium. Suppose that there are n_0 customers initially and that t is sufficiently small for the chance that the server has been free in $(0, t)$ to be small. Then the number of customers in the queue at time t has mean n_0 and variance $V_a(t) + tC_s^2/\bar{s}$, i.e. the variance is $tC_s^2/\bar{s}$ for regular arrivals and $t(1 + C_s^2)/\bar{s}$ for random arrivals, since $r = \bar{s}/\bar{a} = 1$. We may say rather arbitrarily that an appreciable change from the initial distribution has occurred if there is a 5 per cent. chance that the number in the queue has either doubled or fallen to zero. The time at which this happens is defined approximately by

$$n_0 = 2[V(n(t))]^{\frac{1}{2}},$$

i.e. by

$$t = \frac{\bar{s}n_0^2}{4C_s^2} \quad : \text{ regular arrivals} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

$$t = \frac{\bar{s}n_0^2}{4(1 + C_s^2)} \quad : \text{ random arrivals} \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Formulae (1)–(10) will now be illustrated by numerical examples.

Example A.—Consider a simple queue with a random arrival rate of 1 per minute and a constant service-time of 45 seconds so that $r = 3/4$. The mean queueing-time is, by Pollaczek's equation, $1\frac{1}{2}$ minutes. The number of customers in the queue (Kendall, 1951) has mean $15/8 \simeq 2$ and variance 3·7.

Suppose that the arrival rate suddenly doubles, so that $r = 1\frac{1}{2}$, and that this value is maintained for 1 hour, the arrivals still being random and the service-time unaltered. By equations (1) and (2), the mean and variance of the number of customers in the queue at the end of the hour are approximately 42 and 124. The total queueing-time of the customers joining the queue in this hour is by (5) approximately 1,980 minutes, an average of $16\frac{1}{2}$ minutes per customer.

Suppose that at the end of the hour the traffic intensity returns to its initial value of 3/4. Then in equations (6) and (7), $E(n_0) = 42$, $\bar{s} = 3/4$, $\overline{Q} = 3/2$, $C_s = 0$, $V(n_0) = 124$. Therefore $E(\tau) = 120$, $V(\tau) = 2{,}200$. Thus the effects of the rush hour persist for 2 hours with a standard deviation of about 47 minutes.

Many circumstances could complicate these results in a practical application, for example the

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server may work faster when there is high congestion, the presence of a large queue may deter further customers, the traffic intensity may increase gradually instead of discontinuously, etc.

Example B.—Consider a simple queue in which the average arrival rate exactly equals the average rate at which customers can be served, and suppose that initially there is a moderate queue, say $n_0 = 10$, and that the coefficient of variation of service-time is 20 per cent. Then by (9) and (10), the times the system takes to shift appreciably from its initial position are

$$t = 625\bar{s}: \text{ regular arrivals,}$$

$$t = 24\bar{s}: \text{ random arrivals.}$$

Thus with regular arrivals over 600 customers are served before an appreciable change occurs, so that we can reasonably say that the system remains in apparent equilibrium for a long time; with random arrivals, on the other hand, a change occurs comparatively quickly.

References

ARROW, K. J., HARRIS, T., & MARSCHAK, J. (1951), "Optimal inventory policy", *Econometrica*, **19**, 250–272.

ASHCROFT, H. (1950), "The productivity of several machines under the care of one operator", *J. R. Statist. Soc.*, B, **12**, 145–151.

BAILEY, N. T. J. (1952), "Study of queues and appointment systems in outpatient departments, with special reference to waiting times", *J. R. Statist. Soc.*, B, **14**, 185–199.

BELL, G. E. (1949), "Operational research into air traffic control", *J. R. Aero. Soc.*, **53**, 965–978.

BENSON, F. (1952), "Further notes on the productivity of machines requiring attention at random intervals", *J. R. Statist. Soc.*, B, **14**, 200–210.

—— & COX, D. R. (1951), "The productivity of machines requiring attention at random intervals", *J. R. Statist. Soc.*, B, **13**, 65–82.

—— MILLER, J. & TOWNSEND, M. W. H. (1953), "Machine interference: a solution of some work-load problems arising when an operative has charge of more than one machine", *J. Text. Inst.*, **44**, T619–644.

BROCKMEYER, E., HALSTRØM, H. L. & JENSEN, A. (1948), *The Life and Works of A. K. Erlang*. Copenhagen.

COBHAM, A. (1954), "Priority assignment in waiting line problems", *J. Op. Res. Soc. of America*, **2**, 70–76.

COX, D. R. (1954*a*), "A note on the formal use of complex probabilities in the theory of stochastic processes", *Proceedings of the International Congress of Mathematicians*, to appear.

—— (1954*b*), "A table for predicting the production from a group of machines under the care of one operative", *J. R. Statist. Soc.*, B, **16**, 285–287.

—— & SMITH, W. L. (1954), "On the superposition of renewal processes", *Biometrika*, **41**, 91–99.

FRY, T. C. (1928), *Probability and its Engineering Uses*. New York: van Nostrand.

HERNE, H., & NICKOLS, D. G. (1952), "Stochastic problems of storage systems", *Lecture to Industrial Applications Section, Royal Statistical Society*.

KENDALL, D. G. (1951), "Some problems in the theory of queues", *J. R. Statist. Soc.*, B, **13**, 151–185.

—— (1953), "Stochastic processes occurring in the theory of queues and their analysis by the method of the imbedded markov chain", *Ann. math. Statist.*, **24**, 338–354.

KOLMOGOROFF, A. N. (1931), "Sur le problème d'attente", *Matem. Sbornik*, **38**, 101–106.

KOSTEN, L., MANNING, J. R., & GARWOOD, F. (1949), "On the accuracy of measurements of probabilities of loss in telephone systems", *J. R. Statist. Soc.*, B, **11**, 54–67.

LADERMAN, J., LITTAUER, S. B. & WEISS, L. (1953), "The inventory problem", *J. Am. Statist. Assoc.*, **48**, 717–732.

LINDLEY, D. V. (1952), "The theory of queues with a single server", *Proc. Camb. Phil. Soc.*, **48**, 277–289.

—— (1952), "Marshalling and queueing", *Operational Research Quarterly*, **3**, 4–16.

MURDOCH, J. (1952), "The statistical approach to congestion problems in industry", *Lecture to Industrial Applications Section, Royal Statistical Society*.

PALM, C. (1943), "Intensitatsschwankungen im Fernsprechverkehr", *Ericsson Technics*, **44**, 1–189.

SIMAIKA, J. B. (1949), "On the problem of over year storage", *Proc. Egypt. Acad. Sci.*, **5**, 43–51.

SMITH, W. L. (1953*a*), "On the distribution of queueing times", *Proc. Camb. Phil. Soc.*, **49**, 449–461.

—— (1953*b*), "Stochastic sequences of events", *Ph.D. thesis*, University of Cambridge.

TANNER, J. C. (1951), "The delay to pedestrians crossing a road", *Biometrika*, **38**, 383–392.

TIPPETT, L. H. C. (1935), "Statistical methods in textile research; uses of the binomial and Poisson distributions", *J. Text. Inst.*, **26**, T13–17.

VOLBERG, O. (1939), "Problème de la queue stationnaire et non-stationnaire", *Comptes Rendus (Doklady) Acad. Sci. U.R.S.S.*, **24**, 657–661.

WARDROP, J. G. (1954).—"The capacity of roads", *Operational Research Quarterly*, **5**, 14–24.

The two papers by D. G. Kendall contain an extensive bibliography of theoretical work on congestion. There are frequently papers on congestion problems in *J. Op. Res. Soc. of America* and in *Operational Research Quarterly*.

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Agricultural Income

By J. R. Bellerby

The statistical work for the estimates in this paper has been widely shared. Substantially all the basic material comes from the statistical services of public Departments, and as regards the farm income series from 1937/8 to 1952/3 much of the material has been processed by them to a final stage. For the earlier series the construction has involved co-operation by members of the staff and others associated with the Agricultural Economics Research Institute in Oxford, including initially E. M. Ojala and A. J. Boreham, and later K. E. Hunt and D. K. Britton. More recently F. D. W. Taylor and the writer have worked on sections of the estimates and on the preparation or collection of series for different types of income comparison. Reference is made in the text to specific contributions by some here mentioned, but their responsibility is broader than the references suggest and the present findings are at many points a combination of results in which authorship is not separable.*

It will be convenient to divide the series into three groups of years, 1937/8–1952/3, 1923–38 and 1867–1914.

1937/8–1952/3

For the period from the harvest year† 1937/8 onwards it is proposed to compare the farmer's income with industrial wages—a purpose involving an adjustment to exclude the return to property from the farmer's income. As the remainder represents the payment for management, risk-bearing, effort and all functions of the entrepreneur except those of proprietor, the broad term "incentive income", rather than "labour income", is used to describe it.

The total incentive income of farmers and their co-working relatives is obtained by estimating the total factor income of agriculture and subtracting from it (i) net agricultural rent, (ii) an allowance for interest on occupiers' capital, (iii) the wages and salaries of employees, and (iv) the incentive income of any independent workers in agriculture who are not ordinarily classed as farmers, for example, nurserymen and machinery proprietors. Incentive income per man-unit in the farm-operator group—the final aim of the calculation—is the residual figure divided by the number of independent farm operators, including relatives engaged on the work of the farm, reduced to man-equivalents.

Sources and Methods

The first six lines of Table 1 contain estimates compiled by the statistical staff of the Ministry of Agriculture and Fisheries in collaboration with the Department of Agriculture for Scotland and the Northern Ireland Ministry of Agriculture, and we gratefully acknowledge the permission to reproduce them here. Some of the methods used in the Departmental calculations are described by L. Napolitan in "National Output and Income Accounting in Agriculture".‡ Regarding gross output (line 1 of the present Table 1) he says, "The Agricultural Departments define gross agricultural output as that part of total agricultural production which leaves the 'national farm'. It represents, in other words, sales from farms to the non-farm community together with the quantity consumed in farm households. The quantity of output is valued item by item at 'farm-gate' prices ... Changes in stocks—that is changes in the acreages under crops and numbers of livestock

* For further references see *Farm Economist*, 1952–4; E. M. Ojala, *Agriculture and Economic Progress*, Appendix on Gross and Net Output of Agriculture; and *Journal of Proceedings of the Agricultural Economics Society*, 1953–5.

† Harvest years, June–May, are distinguished throughout by the use of the oblique stroke, whereas 1937–8 implies the average for two complete calendar years.

‡ The initial paper in a symposium on "Agricultural Output and Income", *Farm Economist*, 1953. A contribution by O. J. Beilby is published in the same number as "Discussion: with special reference to the Expanded Sample of Financial Accounts".

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TABLE I

United Kingdom : Farmer's Incentive Income and Industrial Wages, 1937/8–1952/3

		1937/8	1938/9	1939/40	1940/1	1941/2	1942/3	1943/4	1944/5	1945/6	1946/7	1947/8	1948/9	1949/50	1950/1	1951/2	1952/3(a)
1. *Gross Output*(b)	£m.	302	294½	358½	453	500½	563	599	582	624	615½	717½	833½	906	935	1,049	1,156
2. *Total Farm Receipts*(c)	£m.	306	298	375½	491¼	533¼	579½	620½	595½	642½	655½	743	863	963	1,003½	1,151½	1,222
Extra-farm Expenses																	
Occupier:																	
3. Machinery (repairs, depreciation, fuel, etc.)	£m.	15½	16	19	26½	34½	41½	45	48½	52	57½	70	73	84	103	123	139
4. Feedingstuffs	£m.	78	68½	66½	61	41	28½	31	32	43	34	43½	61½	113½	142½	177½	187
5. Fertilizers	£m.	8½	9	12½	17½	22½	26	29½	28½	29½	30	36½	39½	45	54½	54	71½
6. Other(d)	£m.	38½	41	49	55½	65	78½	84½	85½	88½	92½	102½	116	123½	141	155½	166½
Landowner:																	
7. Statutory charges, insurance, and material and services not supplied by farm or estate labour(e)	£m.	8½	8	8	8½	9½	10	10	10	10½	11	11	12	12½	13	14	14½
8. Adjustment for retail valuation of self-supplies	£m.	6½	6½	8	9	9½	7	3	2½	1½	0	½	3½	2	2½	6½	6½
9. *Total Factor Income*	£m.	163½	162	228	331½	370½	402	423½	393½	420½	430½	479½	564½	586½	552	634	650
10. Wages, etc.	£m.	63	63	69	94	113	134	146	158½	170½	197	211½	222½	225½	228½	240	248½
11. Interest on occupiers' capital	£m.	18	20	22½	26	30½	34	36½	37½	37½	37	39	45	52½	60	67½	75½
12. Net rent	£m.	20½	22	21½	21	20	19½	20	20	20½	20½	20½	21	22	22½	23	23½
13. Farmers' incentive income	£m.	61½	57½	115½	190½	207	215	221½	177	192½	176½	208	276	287	241	303½	302
14. Farmers and relatives working on the farm, man-units	000	460·0	460·0	467·0	473·0	480·0	487·0	493·0	500·0	500·0	498·4	494·8	491·8	489·8	487·9	483·1	480·0
15. *Farmers' incentive income per man-week*	£	2·58	2·40	4·75	7·74	8·30	8·48	8·63	6·81	7·40	6·80	8·09	10·79	11·26	9·50	12·09	12·11
16. *Industrial average weekly wage rate*	£	3·16	3·25	3·36	3·66	3·90	4·25	4·50	4·81	5·12	5·48	5·80	6·00	6·12	6·39	7·00	7·55
17. Ratio (15) : (16)	%	82	74	141	211	213	200	192	142	145	124	139	180	184	149	173	160
18. Ratio (15) : Industrial average weekly earnings	%	—	69	123	169	164	149	140	112	126	112	126	156	157	125	145	135

See text for general description of series. Derived figures are from original data before rounding.

(a) Provisional.
(b) Gross output as defined in *Agricultural Statistics*, United Kingdom, Part II, 1949, H.M.S.O.
(c) Gross output plus sundry items of receipts, including direct grants and subsidies. Whereas, for gross output, stocks are valued at market prices, for income purposes breeding stocks are on a replacement cost basis, and slaughter store, growing crops etc., on a cost of production basis.
(d) Excluding capital expenses, interest on short-term credit, and other factor costs.
(e) The landowner's payments to estate workers are included in "Wages etc."

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on farms—are then added to, or subtracted from, the total of sales off farms and farmhouse consumption".

As a further step in estimating aggregate farm income "a total receipts figure is derived by taking the value of gross agricultural output* . . . and adding to it the amount of direct government grants and subsidies to agriculture (such as the calf rearing, hill sheep and cattle subsidies) and also certain small sundry receipts. The value of gross output already includes subsidies paid as a part of, or supplementary to, the price received by the farmer". An estimate of total farm receipts is thus reached corresponding to the figures in line 2.

After this point there is a divergence in *purpose* between the official estimates of the Agricultural Departments and those presented in Table 1. The object of the Departmental calculations is to indicate the amount of "the remuneration of the farmer and his wife for their manual labour, the reward for the farmer's managerial skill and enterprise, and the return on his capital investment. It is the fund from which the farmer has to provide for part, at least, of future investment in his farm, the payment of taxes, his living expenses and other non-farm commitments".† The aims in the present paper are, as noted, to provide a measure of the total factor income of agriculture and then to break down the total into net rent, interest, wages and the farmer's incentive income, for purposes of various comparisons. In consequence, the deductions under the heading of expenses, lines 3–7, from "total farm receipts", line 2, are less in number and amount than those which appear in the published Departmental calculations.

Some of the sources used in assessing these expenses are mentioned in Mr. Napolitan's paper in the *Farm Economist*, 1953, and details of outlay on fertilizers are given in the *Agricultural Statistics of the United Kingdom*, Part II, 1943/4–1949/50. In general, the gauging of the national totals of the various expenses is a co-operative task involving the aid of other Departments, including the Ministries of Food and Fuel and the Board of Trade. All the costs shown in lines 3–6 are incurred by farmers for materials or services purchased from abroad or from non-farm domestic producers. They are thus "extra-farm expenses", and they represent the outgoings of occupiers in their capacity as farm operators.

Landowners also incur considerable extra-farm costs. Statutory charges on the land include tithe annuities, land tax, and drainage and other rates; and there are insurance charges and certain expenses of management entailing payments to non-agricultural enterprise. Repair and upkeep on large estates involve payments to outside contractors and suppliers of material, which in total probably exceed half the outlay for physical maintenance of the estates.

Information on landowners' expenses in England and Wales is given in the periodical reports of the Country Landowners' Association, and this has been applied for purposes of line 7 in accordance with the definition of net rent used in this paper. Net rent is defined as the actual payment to the landlord by the tenant, less the rent of dwellings, and less statutory charges on the land, and such maintenance costs as would be necessary to keep the land and farm buildings in an unchanging satisfactory state of repair. During the late war repair was limited, but since 1946 much work has been done not merely to restore estates but also to improve them. The estimates in line 7 are the continuation of an annual series, beginning in 1867,‡ in which there has been some smoothing to remove sporadic fluctuations in upkeep and restoration.

Retail Valuation of Self-Supplies

For purposes of income comparisons it seems desirable to value the farmer's self-supplies at retail prices—at rural retail prices first, if the intention is later to adjust the whole incentive income of farmers according to the general difference in rural and urban retail prices.

Estimates of gross output arrived at by the methods used in the Departmental calculation automatically include the farm families' consumption of their own produce; but this is initially valued, with all other "output", at farm-gate prices. Revaluation at retail prices calls for an annual series showing the effect of wartime and post-war food subsidies on the margin between the farm

* For purposes of income estimates the method of valuation of stocks differs from that used for gross output—see footnote[(c)] to Table 1.

† L. Napolitan, *ibid.*, p. 197.

‡ The results of an investigation into one of the largest items, tithe rentcharge, are given in "Aggregate Tithe Rentcharge on Farm Land in the United Kingdom, 1867–1938", in the *Journal of Agricultural Economics* for 1955. Estimates of annual change in the total margin between gross and net rent since 1867 appear in the same *Journal* for March 1954.

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and retail prices of the chief self-supplies. According to estimates by F. D. W. Taylor the margin fell from about 50 per cent. of the farm price in 1938 to an insignificant figure in 1946, and thereafter rose to 16 per cent. in 1952. The adjustment based on these calculations for purposes of line 8 leads to the estimate of the total factor income of agriculture, line 9.

Wages

Concerning the division of the factor income into its parts, it may be recalled that "wages, etc." includes the incentive income of certain groups of independent producers not classed as farmers, the chief group being market gardeners and nurserymen.

The series in line 10 is linked at 1937–8 to an independently calculated wage series for 1867–1938. The process of linking involved the fairly close reconciliation of the independent estimate for 1937–8 with the Agricultural Departments' aggregate of wages, differently defined, for the harvest year, 1937/8. For the later part of the series for 1937/8 to 1952/3, estimates of "wages, etc." were made for particular harvest years, 1946/7, 1950/1 and 1951/2, by adjusting the official wages aggregates to eliminate from them the allowances for family labour,* and to include payments to managers and estate agents, together with the estimated incentive income of the independent producers above-mentioned. Figures for intervening years were interpolated, the official aggregates being used as index.

TABLE 2

United Kingdom: Specified Farm Factor Costs and Aggregate Farming Net Income (Departmental Definition) (a) £ *million*

	(1) *Aggregate Cost of Labour*(b)	(2) *Rent and Interest*(c)	(3) *Net Income*(a)
1937/8	66	43	56½
1938/9	66	43½	54
1939/40	72½	45	111
1940/1	99	46	186
1941/2	119½	46	205
1942/3	141½	45½	218
1943/4	154½	46	230
1944/5	168	47	186
1945/6	180½	47½	201½
1946/7	209	50	182½
1947/8	224½	50½	215½
1948/9	236½	53	283½
1949/50	239½	57	300½
1950/1	243	60	259½
1951/2	255	65½	321
1952/3	264½	69	324½

(a) See earlier quotation from L. Napolitan.
(b) Aggregate payment by farmers to employees and remuneration of relatives engaged in the work of the farm.
(c) Rent on agricultural land and buildings (excluding dwellings) and interest paid on short-term accommodation. The remaining interest on occupier's capital is in column 3.

Interest and Rent

Assessment of the return to occupiers' *capital* involves the assembly of series showing what capital expenditure has been incurred by farmers, together with the cash reserves they have needed, for developing their enterprises and maintaining them at current levels. Table 3 gives estimates made by Mr. Taylor according to methods similar to those described in the *Farm Economist*, 1953, pp. 260–2 and 1954, pp. 306–7. Footnotes to the table indicate certain changes in the percentages which have been applied to aggregate values to give the estimates of capital.

* We are indebted to the Ministry of Agriculture and Fisheries, the Department of Agriculture for Scotland and the Northern Ireland Ministry of Agriculture for information both on the number of farm family workers in the three Kingdoms and on the wages attributed to them in the official aggregates. The official estimates of aggregate wages are shown in Table 2 together with other factor costs. In the third column is given the return to farm occupiers or aggregate farming net income as defined by the Agricultural Departments.

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The interest rate applied to the totals in col. 5 is 1 per cent. above the current Consol yield. For each year this gives an aggregate of interest, *I*, which would represent a suitable total charge if all capital expenditure were incurred within the one year. But in respect of the output of any harvest year much of the capital cost arises in the previous year, and for livestock, especially cattle, the outlay extends over a longer period. Accordingly the total interest charge for any year, *x*, has been assessed by means of a 3-year moving average of *I*, covering years x, $x - 1$ and $x - 2$.

The *net rent* estimates in line 12 in Table 1 are a continuation of the series in "Gross and Net Farm Rent in the United Kingdom, 1867–1938", mentioned earlier. For the period since 1938 the chief published sources for gross rent have been the official acreage returns coupled with an index of rent per acre derived primarily from the Country Landowners' Association Report for 1950 and 1951. The Inland Revenue Schedule A valuations for the United Kingdom were used extensively in the assessment of aggregate gross rent up to 1938. Reference was made also to D. K. Britton's Report on an Enquiry into agricultural rents and the expenses of landowners in England and Wales, 1938 and 1946, conducted jointly by the Central Landowners' Association and the Ministry of Agriculture. The Report, together with a memorandum by H. A. Rhee, is published by the Association in *The Rent of Agricultural Land in England and Wales, 1870–1946*. A parallel work for Scotland, relating to 1937/8–45/6, is *Scottish Farm Rents and Estate Expenditure*, H.M.S.O., Edinburgh, 1948.

TABLE 3

United Kingdom : Farm Occupiers' Capital, 1937/8 to 1952/3 £ *million*.

	(1) *Livestock*[a]	(2) *Crops*[b]	(3) *Machinery and Implements*[c]	(4) *Other Items*[d]	(5) *Total*	(6) *Col. 5 Lagged*[e]
1937/8	186	148	85	30	448	439
1938/9	185	171	85	31	472	455
1939/40	205	243	91	35	575	498
1940/1	227	347	100	41	715	587
1941/2	246	435	117	44	842	711
1942/3	258	466	134	46	904	820
1943/4	268	461	143	47	919	888
1944/5	278	459	148	48	933	918
1945/6	290	468	158	51	967	940
1946/7	309	461	177	52	999	966
1947/8	348	499	207	58	1113	1026
1948/9	411	539	241	68	1259	1123
1949/50	440	543	273	78	1334	1235
1950/1	456	588	311	88	1443	1345
1951/2	493	605	337	93	1529	1436
1952/3	557	610	351	98	1615	1529

Derived figures are from original data before rounding.

[a] Capital represented by the value of cattle, sheep, pigs, poultry and horses, assessed at the current year's store prices.

[b] Capital required for the production of wheat, barley, oats, rye, mixed corn, potatoes, sugar beet, beans, peas, turnips and swedes, mangolds, straw, hops, hay, flax, mustard, fruit and vegetables, estimated at 84 per cent. of the total value of the production of these crops in 1937/8, falling to 80 per cent. in 1942/3.

[c] *Sources.*—Value of machinery and implements per 100 acres: Farm Management Survey Reports for England and Wales. Aggregate value of machinery and implements in Scotland: supplied direct by the Department of Agriculture for Scotland. Lorries, vans, and cars: *Monthly Digest of Statistics* for numbers of agricultural lorries and vans; an article by Britton and Keith in *Farm Economist*, April, 1950, for horse-power of lorries and vans and aggregate horse-power of cars. Board of Trade's Indexes of Prices of Industrial Manufactures and Prices of Materials used in Mechanical Engineering: *Annual Abstract of Statistics*.

[d] Includes stocks of purchased feed at current prices and a miscellaneous group assessed at 5 per cent. of all other capital.

[e] Three-year moving average of col. 5. This series is used for Table 5, col. 12. Each of the columns 1 to 4 should be separately lagged in order to make it a more accurate expression of original or historical cost, depreciated where necessary. The largest items in "machinery and implements", col. 3, already reflect depreciated original cost.

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Farmer's Incentive Income per Man-Unit

Justification for including in the same group with the farmer any relative who works with him in the fields is based on the recognition that the essential functions of enterprise and management are often shared between them and that, in the absence of a contract, the relative's income depends on the current revenue of the farm. The number of women and youths in the farmer-and-relative group is not large. Methods of conversion to man-equivalents vary according to circumstances, a common method being to include women and girls at two-thirds, and youths at three-quarters, of a man-unit.

As regards the estimates of man-units in line 14, Table 1, that for 1937/8 is part of a historical series constructed from Census returns. For 1946/7, 1950/1, and 1951/2 the basis is a series of figures received direct from the Agricultural Departments, adjusted to conform to the required definition in man-equivalents. Entries for other years were imputed. By the division of these figures into the aggregates in line 13 a series of "farmers' incentive income per man-unit" is derived, which may be compared with the average of the wage rates of a representative group of industrial trades, line 16.

The Comparison with Industrial Wages

In view of the well-tested representative character of Bowley's wages index it was decided to construct a series of industrial wages from a weighted average of the rates paid in fourteen primarily male occupations covered by his index. The trades are: bricklayers, bricklayers' labourers, compositors, engineering fitters, engineering labourers, dock workers, tram and bus drivers and conductors, Local Authority labourers, coal-miners, railway engine-drivers, railway goods porters, shipwrights, unskilled shipbuilding workers and lorry-drivers. In carrying back the index into the nineteenth century it was not possible to continue some of the individual series, but a fairly representative average was obtained with the aid of supplementary data from the *Abstracts of Labour Statistics* and G. H. Wood's collection of wage rates.*

Wage rates may seem less satisfactory than average labour earnings for a comparison with the farmer's incentive income, but in practice both types of wage series show some defect for long-period comparisons. In the construction of an average of the earnings of any trade there is an unavoidable arbitrary element in deciding how many occasionally unemployed, part-time or casual workers should be covered by the average. If this difficulty is avoided by excluding the unemployed and part-time workers altogether, a series of full-time labour earnings is produced which is a valid basis of comparison only when substantially all wage-earners are fully employed.

The broad conclusion is that an average of industrial wage rates is more satisfactory for use in the depression period before 1939, and that for the long phase of full employment following that date an average of full-time earnings is more suitable. In Table 1 both comparisons are made. For line 18 the index used is the Ministry of Labour's series of average earnings of adult male manual labour,† which excludes part-time workers engaged for not more than 30 hours in the week. The difference between wage rates and earnings was of course very large during the war. Although the gap narrowed immediately afterwards, it widened again as from 1948/9.

1923–1938

Comparability between the estimates for 1937/8–52/3 in Table 1 and those for 1923–38 in Table 4 is close, inasmuch as the two series are derived from a similar range of sources. For the earlier period independent annual estimates of gross output were made for each principal farm product from official returns of acreage, yield, livestock numbers, import and consumption and from relevant unofficial records; but in every case it was possible to compare, for purposes of reconciliation, the average gross output estimated in the independent series for the calendar years 1936–8 with the official return for the last three pre-war harvest years. As regards inputs, construction of the earlier series involved recourse to J. H. Kirk's figures in the *Journal of Proceedings of the Agricultural Economics Society*, 1946, and to official estimates such as those which appear under "occupiers' extra-farm expenses" for 1937/8 in Table 1. A link at 1937–8 and fairly close uniformity

* *Statistical Journal*, culminating in 1909; and an unpublished collection in the Royal Statistical Society's Library.

† Readings from a graph of the series.

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TABLE 4

United Kingdom : Farmers' Incentive Income [a] *and Industrial Wages* 1923 to 1937–8

		1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937–8
1. *Total Farm Receipts* (adjusted) ([a])	£m.	297	314½	301½	284½	278½	285	283½	263	242	245½	262	280½	276	298	295
Extra-farm Expenses																
Occupier:																
2. Machinery (repairs, depreciation, fuel, etc.)	£m.	10	11	11½	11	11	11	11	10	9½	10	10½	11½	12½	13½	15½
3. Feedingstuffs (adjusted) ([a])	£m.	52½	71½	65	51	63	66½	66	44	42	48½	44½	51	50	56½	68
4. Fertilizers	£m.	13	12	11	10½	9½	8½	8	7½	7½	8	8½	9	9½	9½	9
5. Other	£m.	35	40½	40	39½	38½	38½	38	35½	33½	32	32½	32	32½	34½	37
Landowner:																
6. Statutory charges, insurance, and material and services not supplied by farm or estate labour	£m.	11½	11½	11½	12	12	12	12½	12	12½	12	11½	10½	10½	10	9
7. Adjustment for retail valuation of self-supplies	£m.	7½	7½	7½	7	6½	6½	6½	6½	6	6	6	6	6	6½	6½
8. *Total Factor Income*	£m.	182½	175½	170	167½	151½	155	154½	160	143½	141½	160	172	167½	181	163
9. Wages, etc.	£m.	61½	63½	68	70½	70½	70	69½	66½	64	61½	60½	60	61½	61½	62½
10. Interest on occupier's capital	£m.	38½	31	28	28½	28	27½	27	26½	24½	22	19	18	17	17	18
11. Net rent	£m.	24	24	24	22½	21½	20½	20	19	18½	18	17½	17½	17½	18½	20½
12. Farmers' incentive income	£m.	59	57½	50	46	31½	37½	38½	48	36½	40½	63½	76½	71½	83½	61½
13. Farmers and relatives working on the farm, man-units	000	498·7	493·9	489·1	484·3	479·4	474·6	469·8	464·9	460·1	460·1	460·1	460·1	460·1	460·1	460·1
14. *Farmers' incentive income per man-week*	£	2·27	2·23	1·97	1·82	1·26	1·52	1·57	1·99	1·52	1·69	2·65	3·20	2·99	3·50	2·57
15. *Industrial average weekly wage rate*	£	2·99	3·02	3·07	3·06	3·06	3·04	3·02	3·00	2·97	2·92	2·90	2·93	2·97	3·04	3·17
16. Ratio (14) : (15)	%	76	74	64	59	41	50	52	66	51	58	91	109	101	115	81

Sources.—The table is based on the researches of contributors mentioned at the beginning of this paper and in the *Journal of Proceedings of the Agricultural Economics Society*, February, 1953 and March, 1954, where there are descriptions of the series presented as averages for groups of years. Some revisions have been made in reproducing the material here, as annual estimates, for comparison with those for 1937/8–52/3.

([a]) Derived figures are from original data before rounding. All series agree in definition, so far as possible, with the corresponding series in Table 1. In view of the nature of the basic material, however, it was found that the most convenient procedure for estimating the farmers' receipts from sale of wheat, barley and oats was to deduct, from the value of the home production of these grains, the total amount used on the farm for seed or animal feed, including the amount imported for the purpose. This method yields an adjusted total of farm receipts somewhat less than the official estimate of "total farm receipts", Table 1. The margin between the "total farm receipts" for 1937/8 in Table 1 and the average of "total farm receipts (adjusted)" for 1937 and 1938 in Table 4 is accounted for chiefly by differences relating to (i) the treatment of imports of wheat, barley and oats for farm use, (ii) the method of valuing changes in the inventory of livestock and (iii) the period covered. As the item "feeding stuffs (adjusted)" in Table 4, line 3, differs from the category "feeding stuffs" in Table 1 by excluding imports of wheat, barley and oats for farm use, the principal adjustments here mentioned are mutually offsetting; and the others have no effect on the long-term average of the estimates of total factor income.

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TABLE 5

Agricultural Income and Property, 1867–1952/3

Annual Average	(1) *Total Factor Income* £m.	(2) *Net Rent* Aggregate £m.	(3) *Net Rent* % of (1)	(4) *Interest* Aggregate £m.	(5) *Interest* % of (1)	(6) *Wages, etc.* Aggregate £m.	(7) *Wages, etc.* % of (1)	(8) *Farmer's Incentive Income* Aggregate £m.	(9) *Farmer's Incentive Income* % of (1)	(10) *Incentive Income Ratio*[a] %	(11) *Ratio of Farmer's Incentive Income to Industrial Wage Rates* %	(12) *Value of Property* Occupier's Capital £m.	(13) *Value of Property* Land £m.
1867–78	150	35½	24	20	13	54	36	40½	27	69	70	478	848
1879–96	115	28	24	15	13	45½	40	26½	23	37	39	385	715
1897–1914	124½	24	19	15	12	44½	36	41½	33	46	54	387	607
1923–29	165	22½	13	30	18	67½	41	45½	28	48	59	541	408
1930–38	161½	18½	12	20	12	62½	39	60½	37	67	84	429	418
1946/7–52/3	557	22	4	54	10	225	40	256½	46	—	159(b)	1,237	494

Sources.—See foot of Table 4.

(a) The percentages given in this column show the ratio of (i) the farmers' incentive income per man-unit to (ii) the incentive income per man-unit of all (both independent and employed) non-farm producers—estimated by the writer from A. R. Prest's national income series, *Ec. Jour.*, 1948, and historical estimates of national non-farm property by Giffen, *The Economist*, and Stamp. The numbers of non-farm producers in man-units are from F. D. W. Taylor's records of Census returns and of Booth's adjusted data in the *J. R. Statist. Soc.*, 1886.

(b) 137 per cent. when the farmers' incentive income is expressed as a ratio of industrial average weekly *earnings*.

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of method from 1923 to 1952/3 was maintained for landowners' extra-farm expenses and net rent. Mention has already been made of the continuity in the series of farm wages. Interest on occupiers' capital for 1923–38 is based on a series by A. J. Boreham, compiled according to principles which were followed also in the later estimates.

Interpretation

The experience of British agriculture after the First World War is shown in striking contrast to conditions in the second post-war period. In 1923–9 the ratio of the farmers' incentive income to industrial wages was probably not above 60 per cent. In 1946–53 it is estimated to have been about 159 per cent.

Intermediate between the two states of prosperity and depression is the position reached in the late 'thirties when the Government's measures included the de-rating of farm land, continuance of the sugar-beet subsidy, the levy-subsidy for wheat, Exchequer subsidies for milk, cattle, oats and barley, control of imports of bacon by license, some limitation of imports of eggs and milk products, and the creation of marketing boards for milk, potatoes, pigs and bacon, and hops.

In comparisons over time it is important to note the effect of changes in the interest charge on the residual amount of incentive income. In the 'twenties the interest rate, that is Consol yield plus 1 per cent., was continuously high, averaging 5·47 per cent. for 1923–9, but later there was a decline to about 4 per cent. in 1934–6. During the second post-war phase the rate rose steadily from below 4 per cent. in 1946 to 5 per cent. in 1951/2.

1867–1914

As the pre-1914 series includes all Ireland, comparability with the later period is not good: the farmer-and-relative group in Ireland outnumbered that in Great Britain and had a considerably lower standard of living. At the beginning, in 1867, whereas the term "Golden Age" might reasonably be considered to be applicable to Eastern England, large areas of Ireland were still suffering from conditions not far removed from those which caused the Great Famine.

However, the statistics of distribution of income from 1867 to 1914 show certain trends in the shares going to property and labour—trends which are of continuing interest, as they appear to have persisted to the present time.

Aggregate Value of Land and Capital

For purposes of comparing the total value of occupiers' capital with that of land, a broad assessment of the value of land may be made by capitalizing net rent at the annual rates applied to occupiers' capital in assessing aggregate interest. If the land were valued according to the average price per acre currently sold, the total value would appear to have been, at some periods, almost twice that indicated by the method of capitalizing rent. Much of the difference may be attributed to the amenity and security value of land, and the more conservative principle of estimation seems preferable for present needs. The estimates in Table 5 show a ratio of 8·5 of land to 4·8 of capital in 1867–78. In the nineteen-thirties the ratio had turned slightly in favour of capital, and in the post-war years, 1946–53, it had risen to more than 12 of capital to 5 of land.

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The Sources and Nature of Statistical Information in Special Fields of Statistics

The Scotch Whisky Industry

By Ross Wilson, M.A.

The making of Scotch whisky began, and for long continued, as a side-line to farming, the product being intended for domestic and local consumption. It was only in the eighteenth century that distillery production on a large commercial scale began, though without supplanting the domestic manufacture. Both continued together. Towards the end of that century increased attempts at Government regulation and taxation resulted in a long spell of intense conflict and confusion which persisted until 1823. In that year an Act was passed which began the resolution of the problem, initiated the modern era of Scotch whisky distilling and spelt the end of the romantic period of illicit distilling and smuggling.

Up to this time, Scotch whisky had been distilled only in the traditional pot-still, but a few years later a continuous or patent-still was introduced. Both produced Scotch whisky and both are in use to-day.

Originally, the product of each distillery was marketed as a single, or individual whisky, but in the 1860's and 1870's the practice was adopted of blending, according to private formula, the whiskies of several distilleries, both pot-still and patent-still, and marketing the resultant blend in a bottle under a proprietary label. With this development and vigorous salesmanship, began the world-wide expansion of Scotch whisky sales leading to to-day's exports in the region of fourteen million proof gallons a year, with markets still expanding.

Pot-still Whisky

This is also known as malt whisky because only malted barley is used in its production. The method is as follows: barley, already screened, is steeped in water and spread on the malting floor where it is allowed to germinate under controlled conditions. At a certain stage germination is stopped by drying the sprouted grain, or green malt, in a kiln over a peat fire, which also imparts a peaty flavour to the malt. The malt is ground, mashed in hot water, and the resultant sweet liquor, or worts, is fermented by yeast. The weak alcoholic liquor, or wash, is then distilled in a copper pot-still over a coal fire to separate the crude whisky from the wash, and the distillate is then redistilled and the middle running of the second distillation filled into casks to mature. During maturing considerable losses by evaporation take place in the alcoholic strength and volume of the whisky.

Patent-still Whisky

This is sometimes known as grain whisky and its method of manufacture differs from that of malt whisky in two main particulars: first, only a portion of the barley is malted, and secondly, the still, instead of being a pot-still, consists of two columns. Wash, or fermented liquor, is led in at the top of one column, and steam under pressure at the base of the other. During the course of their passage through the columns an exchange of heat takes place resulting in the whisky being vaporised by the steam and later condensed by the wash. In this case, distillation will continue as long as wash and steam are fed into the still. The whisky is then set aside in cask to mature preparatory to blending with other grain and malt whiskies.

Blending

This is an expert operation calling for a high degree of skill, and is not just the mixing of any Scotch whiskies indiscriminately. After the actual blending, the blend is once more put into casks to "marry". This may be for as long as twelve months and is accompanied by further losses through evaporation. The usual branded whisky is a blend of a dozen or more whiskies drawn

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from malt and grain whiskies. No blender is likely to reveal the proportions of the different whiskies he uses.

DEFINITIONS

Scotch whisky.—The Customs and Excise Act, 1952, a consolidating measure, defines Scotch whisky as follows:

"Spirits described as Scotch whisky shall not be deemed to correspond to that description unless they have been obtained by distillation in Scotland from a mash of cereal grain saccharified by the diastase of malt and have been matured in warehouse in cask for a period of at least three years." The word "Scotch" is, in this connection, of geographical, not generic, significance.

Maturing

Because of the maturing time-lag, or, in other words, the interval between the production of whisky and its release for consumption, it is quite impossible, and irrelevant, to attempt to relate production for any one year with consumption for that year. Losses by evaporation, and other causes, must also be taken into account in relating production, consumption and stock figures. Whiskies of different ages and stored under varying conditions will suffer losses at different rates during maturing.

Proof Gallon

The unit of measurement of Scotch whisky, as with all spirits in the United Kingdom, is the proof-gallon. The gallon is the Imperial gallon. Proof is defined by the Customs and Excise Act, 1952, as follows:

"Spirits shall be deemed to be at proof if the volume of the ethyl alcohol contained therein made up to the volume of the spirits with distilled water has a weight equal to that of twelve-thirteenths of a volume of distilled water equal to the volume of the spirits, the volume of each liquid being computed as at fifty-one degrees Fahrenheit." That is, spirit of proof strength is that which, at the temperature of 51° F., weighs exactly twelve-thirteenths of an equal measure of distilled water. Spirit of proof strength is not to be confused with absolute alcohol and the short, rough description of proof spirit is that it is a mixture of absolute alcohol and water in nearly equal measure. It is perhaps worth noting that for measuring and statistical purposes a quantity of spirit of less than one gallon in volume may be a proof-gallon or more if it is sufficiently over-proof in strength. Similarly, a quantity of spirit of more than one gallon in volume may be a proof-gallon or less if it is sufficiently under-proof in strength. In other words, a proof-gallon although occurring on occasion in reality is more truly a notional concept, a unit of measurement.

Original and Re-gauge Gallonage

When Scotch whisky is laid down for maturing its gallonage is recorded as original proof-gallons and its actual gallonage after lapse of time being less because of losses by evaporation, recorded as re-gauge proof-gallons. Stock figures for the industry as a whole are therefore always higher than actual gallonage. That the difference between actual and re-gauge gallonage may be considerable is evidenced by the fact that the customary Excise allowance for losses by evaporation during maturing is 2 per cent. per annum for each year or part of a year plus 2 per cent. for whisky stored in butts and 3 per cent. for whisky stored in hogsheads. Thus the allowance for an eight-year-old whisky stored in a hogshead would be $8 \times 2 + 3 = 19$ per cent. decrease.

Geographical Distinctions

While Scotch whisky is of two main kinds, malt whisky and grain whisky, the malt, or pot-still, whiskies fall into four broad geographical divisions, determined by the location of the distilleries. Of those divisions the principal, and the one in which the Highland malt whiskies are produced, is the wide area of Scotland north of an imaginary line from Dundee on the east to Greenock on the west. Lowland malts are made south of the line; Islay malts in the island of that name off the west coast, and Campbeltown malt whiskies at Campbeltown in the Mull of Kintyre.

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Ireland

Many official figures relating to whisky include whisky made in Northern Ireland as well as Scotland. The Northern Ireland element may be taken to be less than 1 per cent. of the figure where reference is made in the text to "Whisky, Scotch or Irish".

Where relevant in the following tables, figures down to and including the financial year 1921–22 include particulars relating to the Republic of Ireland.

Statistical Sources

The main sources of statistics relating to the Scotch whisky industry are the *Report of the Commissioners of H.M. Customs and Excise*, the monthly *Accounts relating to Trade and Navigation of the United Kingdom*, and, on occasion, *The Annual Statement of Trade of the United Kingdom*, *Hansard*, and figures specially provided by the Commissioners of H.M. Customs and Excise.

Scotch whisky is not separately taxed but only as coming within the definition of spirits for taxation purposes. Consequently the official statistics relating to home production and consumption do not differentiate between Scotch whisky and other dutiable spirits. For exports relating to Scotch and Irish whisky figures are available, but only in so far as spirits for export are declared by the exporter and certified by a Customs and Excise Officer to be Scotch or Irish whisky.

Thus a certain lack of precision prevails and it is impossible to compile an accurate statistical survey of the Scotch whisky industry.

TABLE 1

Distilleries at Work in Scotland

Year ended September 30th	*Distilleries*	*Year ended September 30th*	*Distilleries*
1901	156	1937	86
1910	124	1938	90
1921	134	1939	92
1922	129	1940	93
1923	128	1941	72
1924	124	1942	44
1925	124	1943	33
1926	113	1944	1
1927	84	1945	57
1928	90	1946	80
1929	92	1947	82
1930	94	1948	88
1931	72	1949	91
1932	41	1950	95
1933	15	1951	97
1934	64	1952	97
1935	64	1953	97
1936	66	1954	97

Source: Customs and Excise Reports.

The number of Scotch whisky distilleries at work varies from year to year according to demand which will be affected by general economic conditions and, more particularly, by the rates of duty in the main markets. The home market witnessed startling increases in the spirit duty in 1918, 1919 and 1920. The re-opening of the American market with the repeal of prohibition helped alleviate the depression afflicting the industry in the late 'twenties and early 'thirties, and on the eve of war the industry was avowedly stockpiling. The war years were, of course, exceptional years and are more fully discussed below. All the distilleries numbered as being at work for these years were not producing Scotch whisky. Similarly, for the post-war years, the number shown must be reduced by at least one, a distillery in Scotland not engaged in the production of Scotch whisky.

The export achievements of the industry and the apparently insatiable world-demand for Scotch whisky since the war have brought an unprecedented amount of activity to the distilleries. It must be borne in mind, when studying the much greater number of distilleries at work in, say, the early 'twenties, that a high number of distilleries does not necessarily mean a greater output than a smaller number at work. In the former case, they may not all be working to capacity, and in the latter, improvements may also help increase the amount of Scotch whisky made. No statistical

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record is available of the separate number of Highland, Lowland, Islay and Campbeltown malt distilleries and grain distilleries. There are at present nine grain distilleries operating in Scotland, two malt distilleries at Campbeltown, eight on Islay and the remainder north and south of the Dundee-Greenock line, the bulk being to the north.

An indication of the relative numbers of distilleries producing malt and grain whisky is provided by extracting from Customs and Excise Reports the numbers of distilleries using malt only and the numbers of distilleries using malt and other materials in the production of ethyl alcohol. The numbers of distilleries using molasses only may be disregarded as molasses are not used in the production of Scotch whisky.

TABLE 2

Distilleries at Work in the U.K.

Year Ended September 30th	*Malt Only*	*Malt and Other Materials*	*Year Ended September 30th*	*Malt Only*	*Malt and Other Materials*
1938	82	13	1946	74	8
1939	85	11	1947	75	9
1940	85	11	1948	80	9
1941	64	8	1949	83	9
1942	45	1	1950	86	11
1943	32	—	1951	87	11
1944	—	—	1952	88	11
1945	52	7	1953	88	11

Source: Customs and Excise Reports.

These numbers include, however, Northern Ireland and England and it is necessary to subtract three or four from the malt only column and probably two from the malt and other materials column to approximate to a figure of Scotch whisky distilleries under these heads.

TABLE 3

Production of Ethyl Alcohol in Scotland

Year Ended March 31st	*Original Proof-gallons ('000's)*	*Year Ended March 31st*	*Original Proof-gallons ('000's)*
1901	30,196	1937	24,823
1911	20,021	1938	32,503
1921	29,296	1939	32,581
1922	24,588	1940	27,023
1923	27,096	1941	20,091
1924	27,424	1942	8,030
1925	27,436	1943	9,880
1926	26,027	1944	3,927
1927	16,532	1945	11,319
1928	18,988	1946	19,219
1929	20,512	1947	8,962
1930	20,907	1948	23,783
1931	15,831	1949	29,156
1932	9,232	1950	32,301
1933	5,926	1951	38,078
1934	13,174	1952	39,576
1935	16,869	1953	41,572
1936	20,252	1954	44,316

Source: Customs and Excise Reports.

These figures relate not only to Scotch whisky, but include industrial ethyl alcohol over some years, especially over the war years, and, from September, 1951, the output of a new distillery producing ethyl alcohol for industrial purposes by another method than the fermentation-distillation process. For the period up to 1936–37, however, no other breakdown is available, but Customs and Excise annual reports have now given for some years figures of the production of ethyl alcohol by distilleries using malt only, and by distilleries using malt and other materials. The figures include distilleries other than those in Scotland but for the sake of completeness are given here.

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TABLE 4

Production of Ethyl Alcohol

Year Ended September 30th	*Proof-gallons ('000's)*		
	Distilleries Using Malt Only	*Distilleries Using Malt and Other Materials*	*Total*
1938	10,872	25,443	36,315
1939	10,668	27,099	37,767
1940	7,262	6,402	13,664
1941	3,244	4,751	7,995
1942	1,848	27	1,875
1943	1,388	—	1,388
1944	—	—	—
1945	3,692	6,014	9,706
1946	5,847	8,503	14,350
1947	3,518	5,657	9,175
1948	8,329	12,593	20,922
1949	11,328	16,344	27,672
1950	12,793	16,731	29,524
1951	12,324	16,179	28,503
1952	12,728	18,795	31,523
1953	12,428	14,941	27,369

Source: Customs and Excise Reports.

Production of ethyl alcohol from additional materials, e.g. molasses, need not concern us for the reason given above. But Table 4 includes more than distilleries in Scotland producing ethyl alcohol which is later to become Scotch whisky. It includes, for instance, Northern Ireland.

It is possible to arrive at an estimate of Scotch whisky production over recent years, however, as in Table 5, but this is only an estimate, and one with which many authorities may disagree except for certain years, as noted below.

TABLE 5

Estimated Production of Scotch Whisky. Original Proof-gallons

Year Ended September 30th	*Distilleries Using Malt Only*	*Distilleries Using Malt and Other Materials*	*Total*
1939	10·7 million	18·5 million	29·2 million
1940	7·2 ,,	6·2 ,,	13·4 ,,
1941	3·2 ,,	Nil	3·2 ,,
1942	3·2 ,,	,,	3·2 ,,
1943	Nil	,,	Nil
1944	,,	,,	,,
1945	3·7 million	5·0 million	9·7 million
1946	5·8 ,,	8·5 ,,	14·3 ,,
1947	3·5 ,,	5·6 ,,	9·1 ,,
1948	8·3 ,,	12·5 ,,	20·8 ,,
1949	11·3 ,,	16·3 ,,	27·6 ,,
1950	12,714,699	16,441,708	29,156,407
1951	12,226,252	14,836,548	27,062,800
1952	12,610,279	17,481,710	30,091,989
1953	12,320,980	13,896,666	26,217,646
1954	13,697,676	19,149,220	32,846,896

The figures for 1950 and 1951 above are taken from the *Board of Trade Journal*, the material having been supplied by Customs and Excise, and the figures for 1952 to 1954 were given by the Chancellor of the Exchequer, in response to a Parliamentary Question, and are also based on Customs and Excise information. The 1953 "Malt and other materials" production figure has been severely criticized within the industry as being inaccurate. The value of these four years' figures is that they do provide some measure of comparison by which to judge the earlier years of Table 5 against the same years in Table 4.

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As to the earlier years, the figures in Table 5 are reasonably accurate *for the period* but are not thoroughly reliable for any one specific year. It is possible, for instance, that some of the grain whisky (from malt and other materials) shown in Table 5 as having been made in 1939–40 should more properly be credited against 1940–41.

Mr. W. Birnie, C.A., of Glen Mhor and Glen Albyn Distilleries, Inverness, an acknowledged statistical expert, in his *Statistics Relating to British-Made Potable Spirit* gives the following figures for grain whisky production:

TABLE 6

Grain Whisky Production

Year Ended September 30th	*Original Proof-gallons*
1939 . .	18,535,122
1940 . .	4,135,286
1941 . .	4,751,024
1942 . .	26,570

Again Mr. Birnie adapts the Table 4 (above) figures for malt whisky production for 1941–42, and 1942–43, as follows:

TABLE 7

Malt Whisky Production

Year Ended September 30th	*Original Proof-gallons*
1942 . .	1,847,876
1943 . .	1,387,826

Other experts, on the other hand, consider that a more correct picture is obtained by adding these two quantities together as the make for 1941–42 as in Table 5, and reference should be made to the section below dealing with raw materials which outlines the licence and supply of cereals system during the war and immediate post-war years.

It is from these years that the present problems of the industry stem. The fundamental problem has been, and still is, the insufficiency of fully-matured whisky to meet all needs, and that problem is aggravated by the time-lag due to a necessarily long maturing period. In other words, the difficulty has been how to make whisky go round, and that task has becn rendered more difficult by the constantly rising world-demand. There can be do doubt that had production been allowed to proceed normally during the war, or had full production been resumed in the autumn of 1945, not only would the problems of the industry have been far fewer, but its contribution to the national economy much greater. As it happened, only about as much was made in the six years of the war (29·5 million proof-gallons) as in 1938 or 1939, and it was not until the winter of 1947–48 that any real improvement took place when some 20·9 million proof-gallons, about two-thirds of a normal years's production, were allowed to be made. Since then, with the lifting of one restriction after another, normal production has been resumed.

The resumption of the "normal" rate of production does not solve the industry's problems because of the inescapable maturing time-lag. It is essential to the smooth functioning of the industry to maintain a stock which is well balanced both as to age and to the distilleries from which it is drawn. The war and first post-war years destroyed that balance by interrupting the flow of new whiskies with the result that to-day whiskies insufficiently mature predominate in the industry's stocks and member-firms of the Scotch Whisky Association still find it necessary to ration their releases.

Raw Materials

Substantially the only raw material used in the production of Scotch whisky is barley. No figures are available on the consumption of peat, coal and water, whether for mashing or cooling.

Before the war, distillers were free to use as much barley as they wished. Early in 1940 the manufacture of spirits from cereals was prohibited except under licence and Scotch whisky manufacture for that year was limited to one-third of the quantity distilled in the year ended September 30th, 1939. The patent still, or grain, distilleries, ceased to manufacture after 1940 apart from completing in 1941 the balance of production already licensed. In 1941 malt distilleries were

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licensed to produce one-third of their output in the distilling year 1938–39. In 1942 they were limited to the same amount less 10 per cent. and in the following year allowed only to complete any output previously sanctioned. Towards the end of 1944 malt and grain distillation was allowed to be resumed on a limited scale, and the allocation of cereals allowed an output of approximately one-third of pre-war distillation.

The end of the war did not see the lifting of the limitations on Scotch whisky distilling. In April, 1945, the Prime Minister, then Mr. Winston Churchill, wrote in a Minute:

"On no account reduce the barley for Whisky. This takes years to mature, and is an invaluable export and dollar producer. Having regard to all our other difficulties about exports, it would be most improvident not to preserve this characteristic British element of ascendancy."

Nevertheless it was not until the 1948–49 season that production reverted to normal. Table 8 lists the barley allowances for distilling during the period. Since April 30th, 1950, as the quantity of cereals being licensed was greater than the then total requirements of the industry, the quantitative limitation on distillers was lifted.

TABLE 8

Barley Allowances for Distilling

	Tons ('000's)		*Tons* ('000's)
1939–40	100	1945–46	122
1940–41	35	1946–47	100
1941–42	35	1947–48	150
1942–43	Nil	1948–49	250
1943–44	,,	1949–50	300
1944–45	100		

The barley harvest in Scotland is not great enough to meet the distillers', brewers' and maltsters' demands, and in consequence a substantial quantity of distillers' barley comes from other parts of the United Kingdom. On an average, over the past few years, the proportion of Scottish barley used by distillers has been between 50 per cent. and 65 per cent., the remainder having come from south of the Border. Foreign barley may now also be used and it is interesting to note that the geographical origin of the barley has in itself no effect on the quality of the whisky.

The figures of raw materials given by Customs and Excise do not give the tonnage of raw grain but the weights of malt and unmalted grain used. It is not possible to calculate back from the weight of malt to the weight of raw barley.

TABLE 9

Quantities of Material in Hundredweights Used at Distilleries.

Cwts. ('000's)

Year Ended September 30th	*Distilleries Using*		
		Malt and Other Materials	
	Malt Only	*Malt*	*Unmalted Grain*
1938	1,593	689	2,237
1939	1,537	647	2,156
1940	1,060	178	436
1941	482	256	274
1942	276	2	3
1943	205	—	—
1944	—	—	—
1945	563	290	702
1946	844	364	1,018
1947	510	235	692
1948	1,205	524	1,536
1949	1,643	682	1,967
1950	1,824	654	2,047
1951	1,759	612	2,097
1952	1,832	710	2,426
1953	1,755	532	1,911

Source: Customs and Excise Reports.

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Calculations based on the above figures show that at ethyl alcohol distilleries using malt only, the spirit yield is at the rate of seven proof-gallons per hundredweight of malt, and at distilleries using malted and unmalted cereals, at the rate of six gallons per hundredweight of material.

It is understood in the Scotch whisky industry that a ton of barley, with a moisture content below 14 per cent., will produce 105 proof-gallons of whisky.

Consumption of Scotch Whisky

1. *Consumption of British-made Spirits*

No figures are available before 1938–39 showing the separate consumption of Scotch whisky and no estimate of any degree of acceptable accuracy is possible.

TABLE 10

British-made Spirits, Consumption.

Year Ended March 31st	British-made Spirits Consumed at Home: Proof-gallons. (Millions)	British-made Spirits Consumed at Home: Percentage of Total	British-made Spirits Exported: Proof-gallons (Millions)	British-made Spirits Exported: Percentage of Total	Total British-made Spirits Consumed. Proof-gallons (Millions)
1900 . .	38·7	88·0	5·3	12·0	44·0
1910 . .	21·4	72·7	8·1	27·3	29·5
1920 . .	17·8	80·2	4·4	19·8	22·2
1930 . .	10·6	57·0	8·0	43·0	18·6

Source: Annual Statements of Trade.

The term "British-made spirits" here does not include gin, but does include home-made spirits from which gin was made. Home consumption figures reflect the effects of rate of spirit duty, economic conditions, changing social habits and the changes connected with World War I.

By 1914 exports were around the ten million proof-gallon mark. They declined during the First World War, reaching their lowest point, 2·79 million proof-gallons, in 1918–19, the result of war-time depletion of stocks, prohibition in the United States, and of tariff and excise policies of importing countries. Exports climbed during the 1920's once more, with a peak of 8·23 million proof-gallons in 1924–25, but did not regain their pre-1914 level until the "Cash and Carry" period of World War II.

2. *Consumption of Scotch Whisky*

TABLE 11

Total Consumption of Scotch Whisky

Year Ended March 31st	Scotch Whisky Consumed at Home: Proof-gallons (Millions)	Scotch Whisky Consumed at Home: Percentage of Total	Whisky (Scotch or Irish) Exported: Proof-gallons ('000's)	Whisky (Scotch or Irish) Exported: Percentage of Total	Total Proof-gallons ('000's)
1939 . .	6·9	47·2	7,702	52·8	14,602
1940 . .	n/a	—	10,643	—	n/a
1941 . .	6·2	38·0	9,943	62·0	16,143
1942 . .	5·4	39·5	8,253	60·5	13,653
1943 . .	6·1	55·0	5,006	45·0	11,106
1944 . .	5·8	52·3	5,273	47·7	11,073
1945 . .	4·6	50·9	4,424	49·1	9,024
1946 . .	4·7	48·4	4,997	51·6	9,697
1947 . .	4·7	45·3	5,668	54·7	10,368
1948 . .	3·2	30·1	7,438	69·9	10,638
1949 . .	2·5	23·6	8,113	76·4	10,613
1950 . .	3·0	25·9	8,582	74·1	11,582
1951 . .	3·8	27·6	9,945	72·4	13,745
1952 . .	3·5	23·8	11,203	76·2	14,703
1953 . .	3·9	24·9	11,841	75·1	15,741
1954 . .	4·3	24·4	13,332	75·6	17,632

Source: Customs and Excise Reports.

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TABLE 12

Home-made Spirits: Exports

Year Ended March 31st	*Ethyl Alcohol Proof-gallons ('000's)*
1930	8,035
1931	6,074
1932	5,650
1933	5,411
1934	5,285
1935	5,766
1936	6,980
1937	8,856
1938	9,597
1939	8,955

Year	*Whisky, Scotch or Irish*	*Other Sorts*	*Total*
1939	7,702	1,253	8,955
1940	10,643	1,205	11,848
1941	9,943	978	10,921
1942	8,253	960	9,213
1943	5,006	454	5,460
1944	5,273	231	5,504
1945	4,424	293	4,717
1946	4,997	655	5,652
1947	5,668	713	6,381
1948	7,438	1,077	8,515
1949	8,113	1,037	9,150
1950	8,582	1,161	9,743
1951	9,945	1,560	11,505
1952	11,203	1,982	13,185
1953	11,841	1,545	13,386
1954	13,332	1,621	14,953

Source: Customs and Excise Reports.

It is only from the year 1938–39 that a separation is made of the home-made "ethyl alcohol" export gallonage into its main constituent parts of whisky (Scotch or Irish) and other sorts. Even so, some whisky, it is understood, is included under "Other Sorts". The precise amount is not known.

Having both sets of figures for the year 1938–39 and comparing the separate figures for following years it is safe to assume that the same proportions held true in earlier years, and this is borne out by the experience of those who were in the trade at the time.

There has been, then, a revolution in the proportions of Scotch whisky consumed at home and exported, and the Scotch whisky industry is at present predominantly an exporting one. In the year 1938–39, out of some 14·6 million proof-gallons released, 6·9 million, or 47·2 per cent., were consumed at home and 7·7 million gallons, or 52·8 per cent. were exported, and it is likely that in 1929–30, when figures are available only for "British-made spirits", that the home-consumed percentage of Scotch whisky exceeded the export percentage. Yet by the year 1952–53, out of 15·7 million proof-gallons being released only 3·9 million gallons of whisky, or 24·9 per cent., were going to home-consumption, and it would appear probable that this proportion of 25 per cent. for home may be expected to persist for some time yet.

The tendency for the export trade predominance began during the war when Scotch whisky was shipped abroad in exceptionally heavy quantities to help pay for imports of war material, more particularly during the "cash and carry" phase. It was then that Scotch whisky firmly established itself as this country's greatest single U.S. dollar earning export. As the war progressed whisky exports declined with the need to conserve stocks and as the urgency for exports decreased with the introduction of Lend-Lease.

The Government-sponsored export drive of the post-war years has witnessed the revival of that predominance of export over home trade in Scotch whisky, though it will be observed that the industry began its own export drive in 1945–46, in advance of the official one. For some years

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the grant of cereals for distilling was made conditional on the achievement of "export objectives" agreed between the Scotch Whisky Association and the Government, with a consequent reduction in the amount of Scotch whisky to be made available for the already rationed home market. The home market had been rationed by the Association since March 1st, 1940, but in 1946–47 the home-quota was severely cut in order to release extra gallonage for export. That was the only way to achieve the export objective. There was simply not enough aged whisky to meet all needs, and the home market suffered accordingly. Since the beginning of 1954, the industry has been free of "export objectives" and a Government decreed home-ration, and the Association no longer recommends a home-rationing system to its members. As supplies are still insufficient, rationing persists at home and in many overseas markets, but with this difference, that it is now decided by each individual firm in the light of its own policy and resources. The legacy of the war and post-war years of restricted production is still heavy on the industry.

TABLE 13

Exports of Whisky (Scotch and Irish)

	To All Markets		*To U.S.A.*	
Calendar Year	*Quantity Proof-gallons ('000's)*	*Value £ ('000's)*	*Quantity Proof-gallons ('000's)*	*Value £ ('000's)*
1939 . .	9,367	12,719	4,784	6,985
1940 . .	11,258	16,205	6,972	10,470
1941 . .	8,484	13,578	4,969	8,153
1942 . .	5,541	9,703	3,503	6,240
1943 . .	5,215	9,344	3,421	6,104
1944 . .	4,435	8,116	2,570	4,750
1945 . .	4,681	8,621	2,169	3,938
1946 . .	5,881	10,863	2,848	5,271
1947 . .	6,771	13,580	3,990	8,000
1948 . .	7,896	16,190	4,649	9,542
1949 . .	8,521	18,738	5,002	11,000
1950 . .	9,708	23,326	5,846	16,761
1951 . .	10,628	29,598	6,111	17,922
1952 . .	11,531	33,039	6,301	18,481
1953 . .	13,202	37,768	7,164	20,782
1953 . .	13,691	39,055	7,131	20,885

Source: Trade and Navigation Accounts.

This is as near accurate a picture as it is possible to achieve. Where figures for the same period vary in the Accounts for different years, the later figure has been adopted as allowing for official revision.

Trade and Navigation Accounts have over the years varied their method of presenting figures relating to exports of whisky and other home-made spirits, at one time giving figures of home-made spirits only, at another time giving figures per country (e.g. U.S.A.) only of home-made spirits but supplying separate total export figures for the period to all markets of Scotch and Irish whisky on the one hand, and a total for other home-made spirits on the other. Beginning in 1953, with comparative figures for the previous two years, details have been given of the exports of Scotch and Irish whisky to each market and the totals continued for whisky and for gin and other British compounds and spirits.

The separation between "whisky" and "other" for the annual period was first made (retrospectively) in the Accounts for December, 1949. The "other" element in earlier totals is small, about one-eighth, as Table 14 shows, and during the war the export of gin was prohibited except under licence.

The export figures for financial years given earlier (Tables 11 and 12) from Customs and Excise Reports do not suffer from the confusion in the sources for Table 14, and will act as a further guide to interpreting the accuracy of the these figures.

Of the overseas markets, the U.S.A. is by far the largest and is greater too than the home market, previously the largest single market. The "cash and carry" phase of the war witnessed

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TABLE 14

Exports of Home-made Spirits

Proof-gallons ('000's)

Calendar Year	*Whisky, Scotch and Irish*	*Other Sorts*
1947	6,771	836
1948	7,896	943
1949	8,521	1,062
1950	9,708	1,267
1951	10,628	1,746
1952	11,531	1,599
1953	13,202	1,517
1954	13,691	1,529

Source: Trade and Navigation Accounts.

the first great expansion of the U.S.A. market since its re-establishment after the repeal of Prohibition. The decline which followed was due, as with whisky exports generally, to the need to conserve stocks and to the effects of Lend-Lease. Exports to the U.S.A. began to expand once more in 1945–46 in step with the general first increase in Scotch whisky exports and have continued to increase since. Even so, the market is still rationed for many leading brands of Scotch whisky.

TABLE 15

U.K. Consumption of Spirits and British Spirit Duty

Million Proof-gallons

Year Ended March 31st	*Duty per Proof-gallon*	*Consumption of Home-made Spirits*	*Consumption of Imported Spirits*	*Total Spirit Consumption*
1901	11*s.* (5.iii.1900)	36·7	8·7	45·4
1910	14*s.* 9*d.* (29.iv.1909)	21·4	4·6	26·0
1920	50*s.* (1918, 1919)	17·8	6·4	24·2
1921	72*s.* 6*d.* (19.iv.1920)	15·5	4·7	20·2
1922	—	14·5	3·1	17·6
1923	—	12·9	2·3	15·2
1924	—	12·9	2·4	15·3
1925	—	12·3	2·2	14·5
1926	—	12·1	2·1	14·2
1927	—	10·7	1·7	12·4
1928	—	11·7	1·8	13·5
1929	—	11·3	1·8	13·1
1930	—	10·6	1·6	12·2
1931	—	10·2	1·5	11·7
1932	—	8·9	1·3	10·1
1933	—	8·8	1·2	10·0
1934	—	8·6	1·2	9·8
1935	—	8·3	1·1	9·4
1936	—	9·0	1·2	10·2
1937	—	9·3	1·3	10·6
1938	—	9·2	1·3	10·5
1939	—	9·2	1·3	10·5
1940	—	9·7	1·6	11·3
1941	82*s.* 6*d.* (28.ix.1939)	7·7	2·3	10·0
1942	97*s.* 6*d.* (24.iv.1940)	7·0	3·0	10·0
1943	—	7·7	2·0	9·7
1944	137*s.* 6*d.* (15.iv.1942)	7·9	1·6	9·5
1945	157*s.* 6*d.* (13.iv.1943)	6·8	1·6	8·4
1946	—	6·9	2·0	8·9
1947	—	7·0	3·0	10·0
1948	—	5·2	4·8	10·0
1949	190*s.* 10*d.* (12.xi.1947)	4·9	4·0	8·9
1950	210*s.* 10*d.* (6.iv.1948)	6·1	3·7	9·8
1951	—	7·8	3·6	11·4
1952	—	6·9	2·8	9·7
1953	—	7·5	2·7	10·2
1954	—	8·2	2·5	10·6

Source: Customs and Excise Reports.

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TABLE 16

U.K. Consumption of Spirits.

	1939	1940	1941	1942
	Proof-gallons			
Home-made spirits	9,176,007	9,664,681	7,662,456	6,998,854
Imported brandy, rum, etc.	1,272,877	1,557,072	2,345,625	2,978,648
Total	10,448,884	11,221,753	10,008,081	9,977,502
Made up approximately as follows:				*Million Proof-gallons*
Scotch whisky	6·9	n/a	6·2	5·4
Gin and other home-compounded spirits	1·8	n/a	1·8	2·2
Rum, brandy and other imported spirits	1·3	n/a	1·7	1·7
Medical or scientific use	0·5	n/a	0·5	0·5

Source: Customs and Excise Reports

The apparently disproportionate rise in the sterling value of whisky exports to the U.S.A. from £11 million for five million gallons in 1949 to £16·76 million for 5·8 million gallons in 1950 is explained by the devaluation of the pound in September, 1949. It was then agreed that Scotch whisky importers in the U.S.A. should continue to pay the same dollar prices as previously for Scotch whisky with a consequent greater yield in sterling. Had sales continued at the old sterling f.o.b. price, thus reducing the dollar cost to the U.S.A. by about twenty-nine cents a bottle, it would have been necessary to increase sales to the U.S.A. by about 44 per cent. in order to maintain the pre-devaluation rate of dollar receipts for whisky.

From American sources it would appear that Scotch whisky constitutes about 6 to 7 per cent. of all the whisky consumed in the U.S.A.

TABLE 17

U.K. Consumption of Spirits. Year ended 31st March

	1949	1950	1951	1952	1953	1954
	Proof-gallons					
Home-made spirits	4,893,352	6,098,252	7,750,732	6,893,446	7,516,669	8,165,627
Imported brandy, rum, etc.	4,016,907	3,667,669	3,646,312	2,777,007	2,705,767	2,478,054
Total	8,910,259	9,765,921	11,397,044	9,670,453	10,222,436	10,643,681
Made up approximately as follows:						*Million Proof-gallons*
Scotch whisky	2·5	3·0	3·8	3·5	3·8	4·3
Gin and other home-compounded spirits	3·2	3·5	3·8	3·0	3·4	3·5
Rum (excluding rum for manufacture into gin, etc.)	1·7	1·5	1·7	1·2	1·3	1·2
Other imported spirits	1·0	1·2	1·4	1·2	1·1	1·0
Medical or scientific use (spirits granted rebate)	0·5	0·6	0·7	0·7	0·6	0·6

Source: Customs and Excise Reports.

Table 18 is included for reasons of comparison and gives, too, some indication of the amounts of rum and brandy consumed in the United Kingdom in the decade before the war.

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Year ended March 31st

gallons

1943	1944	1945	1946	1947	1948
7,732,684	7,938,116	6,763,781	6,912,540	6,958,366	5,197,223
2,042,439	1,620,152	1,579,339	2,031,341	3,032,347	4,780,251
9,775,123	9,558,268	8,343,120	8,943,881	9,990,713	9,977,474
Gallons					
6·1	5·8	4·6	4·7	4·7	3·2
1·9	2·5	2·7	2·9	2·9	3·4
1·4	1·0	0·7	0·9	1·9	2·9
0·4	0·3	0·3	0·4	0·5	0·5

Excise Reports.

TABLE 18

U.K. Consumption of Imported Spirits

Million Proof-gallons

Year Ended March 31st	*Rum**	*Brandy*	*Imported Dutiable Spirits other than Rum and Brandy†*
1930	·7	·5	·3
1931	·7	·5	·3
1932	·5	·4	·3
1933	·5	·4	·2
1934	·5	·4	·3
1935	·5	·4	·2
1936	·5	·4	·3
1937	·6	·4	·3
1938	·6	·4	·3

Source: Customs and Excise Reports.

* Includes rum believed to have been used in the manufacture of gin.

† Includes certain quantities entered in liquid gallons and also spirits contained in soap, perfumery and varnish.

TABLE 19

Spirits, Home-made and Imported: Revenue (£'s Million)

Year Ended March 31st	*Home-made (Excise)* £	*Imported (Customs)* £	*Total* £
1901	20·1	5·0	25·1
1910	14·6	3·3	17·9
1920	42·6	16·2	58·8
1930	36·7	5·9	42·6
1931	35·1	5·5	40·6
1932	30·2	4·7	34·9
1933	30·1	4·4	34·5
1934	29·1	4·3	33·4
1935	28·3	4·1	32·4
1936	30·4	4·5	34·9
1937	31·4	4·8	36·2
1938	31·1	4·8	35·9
1939	30·9	4·7	35·6
1940	34·5	6·2	40·7
1941	33·9	11·6	45·5
1942	31·0	15·7	46·7
1943	49·4	18·2	67·6
1944	59·6	17·2	76·8
1945	50·1	13·5	63·6
1946	51·2	16·9	68·1
1947	51·6	24·9	76·5
1948	40·7	42·7	83·4
1949	46·7	44·1	90·8
1950	58·7	39·6	98·3
1951	75·8	38·7	114·5
1952	67·1	29·9	97·0
1953	74·6	28·7	103·3
1954	81·1	26·3	107·4

Source: Customs and Excise Reports.

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Table 19 shows the vast sums contributed by spirits consumers by way of excise. The figure for 1950–51 is exceptionally high because of forestalling on the eve of the budget.

The Home Market: Some Observations

It is only since 1938–39 that figures are available to show how much Scotch whisky is consumed at home, but it may be taken that the proportion of Scotch whisky to total spirits consumed in that year was true of previous years also.

The marked fall in the quantity of Scotch whisky consumed at home, both quantitatively and in proportion to other spirits consumed, has no relation to the popularity of Scotch whisky but rather to its availability. The "black-market" prices obtained for whisky during the war and post-war years are an additional support to this view.

In order to conserve stocks and increase exports, and in view of the restrictions imposed on distilling, the Scotch Whisky Association introduced rationing of the home market on March 1st, 1940. The percentage of supplies released was based on the purchases made by any customer during the year ended February 29th, 1940, which was regarded as the standard period.

TABLE 20

Rate of Scotch Whisky Distribution for the Home Market

From—	*To—*	
March 1st, 1939	February 29th, 1940	100 per cent.
March 1st, 1940	February 28th, 1941	80 ,, ,,
March 1st, 1941	July 31st, 1941	65 ,, ,,
August 1st, 1941	December 31st, 1946	50 ,, ,,
January 1st, 1947	April 30th, 1947	45 ,, ,,
May 1st, 1947	April 30th, 1948	25 ,, ,,
May 1st, 1948	April 30th, 1950	20 ,, ,,
May 1st, 1950	December 31st, 1953	25 ,, ,,

Source: Scotch Whisky Association.

From January 1st, 1953, the quota was very slightly increased, when the allocation for the home market for the year was raised by 150,000 proof gallons to a total of 2,750,000 proof-gallons. The decrease in the quota to April 30th, 1947, represents the industry's concern for safeguarding the stock position. The sudden drop to 25 per cent. from May 1st that year and later to 20 per cent., resulted from the annual agreements with the Government from that date as to export objectives, and home allocations of whisky and releases of barley for distilling. The first Strachey Year (May 1st, 1947 to April 30th, 1948), named after the then Minister of Food, set a home allocation of 2·6 million proof-gallons which was reduced to 2·0 million proof-gallons for the second and third Strachey years. For the fourth year (or the first Webb year) the home allocation was raised to 2·6 million proof-gallons at the insistence of the industry.

From January 1st, 1954, Association member-firms were freed of both Government imposed rationing and the Association quota scheme and left free to distribute their supplies according to their own policy and resources. In the event, they have had to continue rationing at home because of the shortage of fully-matured whisky available to meet all demands.

The difference between the official allocation for home and the actual releases has been due to whisky without the control of members of the Association, who themselves adhered strictly to the agreement and even exceeded the export objectives set them. Exports, which have grown from year to year, have been achieved at the expense of the home market as well as of stocks of fully-matured whisky.

The predominance since the outbreak of the war of exports over home consumption has already been remarked. One further effect of this change has been the replacement of the home market by the U.S. market as the largest single market. The home market is now the second largest world market and it may be expected that the industry will pay increasing attention to rebuilding it, as sufficient mature whisky becomes available, to something of its former self.

Where demand for Scotch whisky will settle at home is a matter for conjecture. The market has been artificial too long for any unquestionable estimate, and consumption of Scotch whisky has been regulated not by demand but by availability. With insufficient supplies of whisky, the public drank other spirits, and, despite the penal increases in the spirit duty since 1939, it would appear that

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United Kingdom spirit consumption has settled around the figure of ten million gallons a year. Improved economic conditions, a changed fiscal policy, and various imponderables, such as buying habits of the public, could no doubt increase this figure.

The years 1950–51 and 1951–52 should be averaged to obtain a true picture as there was heavy forestalling in the former year because of expectations of a further increase in the spirit duty. The drop in 1948–49 may be taken as due to too savage duty increase and also to the greater restriction on the home allocation of whisky.

Figures made available, at request, for the Scotch Whisky Association show the home consumption of Scotch whisky over recent calendar years to have been as follows:

TABLE 21

Home Consumption of Scotch Whisky

Calendar Year	*Million Proof-gallons*
1951 . . .	3·6
1952 . . .	3·8
1953 . . .	4·35
1954 . . .	47·9

Releases of Scotch whisky during 1954 have been heavier than for the corresponding period of 1953, and it may be taken that these have passed at once into consumption because of the heavy duty rate. It would appear, therefore, that Scotch whisky is regaining the position, as supplies become available, which it lost from 1947–50 (financial years) to gin as the premier potable spirit in the United Kingdom.

Turning from the current quantity and proportion of Scotch whisky at present consumed at home to the overall spirit home-consumption picture, the drop in total consumption since the beginning of the century is startling—from 45·4 million proof-gallons of spirits, home-made and imported, in 1900–01 to 10·6 million proof-gallons in 1953–54; and from 36·7 million proof-gallons to 8·2 for home-made spirits over the same period. This drop must be ascribed to the taxation policy of successive Governments. Total spirit consumption in the U.K. has now fallen to less than a quarter of what it was in 1900–01 (from 45·4 to 10·6 million proof-gallons) and the consumption of home-made spirits to almost a fifth in the same period (from 36·7 to 8·2 million proof-gallons). Meanwhile the population of the United Kingdom has risen from 38·2 million in 1901 to 50·6 million in 1953. Direct revenue from spirits has risen approximately fourfold, from £25 million to £107 million since the beginning of the century. For excise on home-made spirits the rise is from £20 million in 1900–01 to £81·1 million in 1953–54.* The rate of duty itself has increased nearly twentyfold: from 11*s.* per proof-gallon to 210*s* 10*d.* per proof-gallon.

If Government policy has been intended to reduce spirit consumption, for whatever reason, it has been outstandingly successful and the time would appear to have come not only for a halt to this policy, but also for a reduction in the rate of duty. There is now little likelihood of nation-wide intemperance. If the policy has been intended as revenue-raising, it is likewise time to reverse the process. It is unlikely that a *substantially* greater quantity of spirits will be drunk in the United Kingdom while the present penal rate of duty is continued. It would be in the immediate interest of the Chancellor of the Exchequer, as additional Scotch whisky becomes available, to reduce the spirit duty, relying on increased consumption to maintain or improve receipts. This would be of long-term benefit to the country as giving the Scotch whisky industry, now predominantly an exporting one, a firmer and more surely solvent home base from which to withstand the shocks and changes of the export trade. A reduction in duty would also set an admirable example to importing countries which, when pressed to reduce, or not to increase, their duties on Scotch whisky point to the U.K. rate of duty.

The present rate of duty of £10 10*s.* 10*d.* per proof-gallon works out at 24*s.* 7·2*d.* per standard bottle of whisky at 70° proof on the home market costing 35*s.* retail. That is, duty represents about 70 per cent. of the retail price. The duties on rum, brandy and other imported spirits and spirits used in making gin, are virtually the same level as the duty on whisky and are kept in close relation to it.

* Admittedly Ireland is a complicating factor.

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There has been no reduction in the duty on whisky since 1895 when 6*d.* per gallon was taken off, leaving the rate at 10*s.* 6*d.* and this 6*d.* was restored in March 1900.

Table 22 shows the relation of duties to Purchase Tax on certain commodities.

TABLE 22

The Incidence of Customs and Excise Duties and Purchase Tax in Relation to the Retailer

Commodity	*Description of Goods Sold to Public*	*Retail Selling Price*	*Duty*	*Duty as a Proportion of Retailer's Cost Price (Exclusive of Duty)*
Alcoholic liquors	1 bottle whisky	35*s.* 0*d.*	24*s.* 7*d.*	401%
	1 pint beer, bitter	1*s.* 4*d.*	8·4*d.*	162%
	1 bottle port	18*s.* 0*d.*	8*s.* 4*d.*	143%
	1 bottle table wine	13*s.* 0*d.*	2*s.* 2*d.*	28%

Purchase tax : Average incidence of tax on wholesale values 43%

Source: Report of the Committee on Tax-paid Stocks. Cmd. 8784. (March, 1953).

The figures speak for themselves. Since the above report was published, however, many more goods have been freed of purchase tax and the tax has been reduced on others. No reduction since then has taken place of the duties on alcoholic liquors.

The growth of the duty on Scotch whisky per bottle within the last twenty years is shown below.

TABLE 23

Spirits Duty

Changes since 1938 in the basic rate of Excise duty on spirits and accompanying changes in the retail price of a bottle of one of the usual brands of whisky.

Date of Change	*Basic Duty per Proof-gallon* £ *s.* *d.*	*Equivalent per Bottle of Whisky of Usual Strength* £ *s.* *d.*	*Retail Price per Bottle of Standard Brand Whisky* £ *s.* *d.*
Pre-1939	3 12 6	8 6	12 6
September, 1939	4 2 6	9 8	14 3
April, 1940	4 17 6	11 5	16 0
April, 1942	6 17 6	16 1	1 3 0
April, 1943	7 17 6	18 5	1 5 9
November, 1947	9 10 10	1 2 3	1 11 0
April, 1948	10 10 10	1 4 7	1 13 4
February, 1951	10 10 10	1 4 7	1 15 0

Source: Report of the Committee on Tax-paid Stocks. Cmd. 8784 (March 1953).

The rise in the retail price in February, 1951, was in order to compensate the retailer because of his extremely reduced turnover in volume of whisky.

To sum up, spirit consumption in the United Kingdom has fallen until to-day it is less than one-quarter of what it was at the beginning of the century, almost entirely as a result of increasing duty. It has declined consistently since the increased duty after the first world war and is now stationary around the ten million proof-gallon mark per annum. Within this framework the vicissitudes of the second world war and the export drive which followed have forced a reduction in the home-consumption of Scotch whisky from which there are as yet only tentative signs of a recovery. Unless the Government wishes to stop the consumption of spirits entirely, it is statistically obvious that the trend of taxation on spirits must be reversed. It can, certainly, go no further in its current direction.

Stocks of Scotch Whisky

Once again we face the problem that no figures relating to Scotch whisky only are available, except, as indicated below, for the past few years during which figures have been supplied at request to the Scotch Whisky Association.

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TABLE 24

Home-made Spirits: Stock in Bonded Warehouses in Scotland

On March 31st	*Original Proof-gallons (Millions)*	*On March 31st*	*Original Proof-gallons (Millions)*
1900	109·9	1937	127·0
1910	115·9	1938	134·9
1920	84·9	1939	144·25
1930	137·2	1940	142·6
1931	137·1	1941	129·6
1932	132·6	1942	114·0
1933	125·0	1943	103·7
1934	121·9	1944	92·0
1935	122·3	1945	84·8
1936	123·9		

Source: Customs and Excise Reports.

These figures contain a *small* quantity of plain methyl alcohol and a rather larger quantity of compounded spirits. For instance, in 1946 there were 1,814 gallons of methyl alcohol and 62,720 gallons of compounded spirits; in 1947 there were 17 gallons of methyl alcohol and 63,821 gallons of compounded spirits. (These are the first years for which such figures are available and are not included in Table 26.) No breakdown or the years above showing the precise amount of Scotch whisky is available, though it may be taken that the great bulk of the stocks consisted of Scotch whisky.

TABLE 25

Stocks of Plain Ethyl Alcohol in Bonded Warehouses in Scotland

On March 31st	*Original Proof-gallons (Millions)*
1946	86·0
1947	79·8
1948	86·7
1949	98·9
1950	111·7
1951	124·1
1952	136·7
1953	148·5
1954	152·3

Source: Customs and Excise Reports.

The reason for the break between 1944–45 and 1945–46 is that Customs and Excise introduced for the Report of the year 1948–49 a breakdown of spirit stocks in Scotland (as elsewhere in the U.K.) and where previously only stocks of home-made spirit had been shown, now gave stock figures for plain ethyl alcohol separately. The figures, however, still include a quantity of ethyl alcohol for industrial use, particularly since towards the end of 1951 when a new distillery in Scotland making industrial alcohol began production.

TABLE 26

Stocks of Scotch Whisky

On	*Original Proof-gallons (Millions)*
September 30th, 1951	127·9
March 31st, 1952	137·8
September 30th, 1952	140·1
March 31st, 1953	145·5
September 30th, 1953	146·2
March 31st, 1954	152·9
September 30th, 1954	157·9

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These figures, supplied at request to the Scotch Whisky Association by Customs and Excise, are the total stocks of plain ethyl alcohol in the U.K. less ethyl alcohol earmarked for industrial purposes and for use in the manufacture of gin or other spirits. Thus Table 26 includes all potential Scotch whisky whether in bond in Scotland or in England. The amount in bond in England is never large in relation to the whole, but it is interesting to observe that the figure of Scotch whisky for March, 1952, in Table 26 (137·8 million) is greater than the corresponding figure (136·7 million) in Table 25.

TABLE 27

Stock, Production and Consumption. Million Proof-gallons

Subject to reservations and explanations made previously, the following table emerges as a guide which is correct in its main outlines but no more.

Year Ended March 31st (Except Column 3, Production)	*Stock*	*Production (Year Ended September 30th)*	*Consumption*		
			Home	*Export*	*Total*
1939 . .	144·25	27·3	6·9	7·7	14·6
1940 . .	142·6	11·2	n/a	10·6	n/a
1941 . .	129·6	3·2	5·2	9·9	16·1
1942 . .	114·0	3·2	5·4	8·3	13·7
1943 . .	103·7	Nil	6·1	5·0	11·1
1944 . .	92·0	Nil	5·8	5·3	11·1
1945 . .	84·8	9·7	4·6	4·4	9·0
1946 . .	86·0	14·3	4·7	5·0	9·7
1947 . .	79·8	9·1	4·7	5·7	10·4
1948 . .	86·6	20·8	3·2	7·4	10·6
1949 . .	98·9	27·6	2·5	8·1	10·6
1950 . .	111·7	29·1	3·0	8·6	11·6
1951 . .	124·0	27·1	3·8	9·9	13·7
1952 . .	137·8	30·1	3·5	11·2	14·7
1953 . .	145·5	26·2	3·9	11·8	15·7
1954 . .	152·9	32·8	4·3	13·3	17·6

The figures in the Stock and Production columns are original proof-gallons, and in the Consumption columns are re-gauge proof-gallons. The industry lost some millions of gallons of stocks through enemy action during the war and this factor must be kept in mind for the relevant years in attempting to correlate the figures. But any such attempt is rendered more difficult by the fact that production figures are related to a different "year" from the other figures. Moreover, there is a constant loss from evaporation and other causes. In normal circumstances, it is estimated, three million gallons a year may be lost by evaporation during maturing.

The author wishes to thank, for their invaluable assistance in compiling this paper, the Intelligence Branch of H.M. Customs and Excise and the Scotch Whisky Association.

The opinions expressed are throughout solely those of the author.

Bibliography

Report of the Commissioners of H.M. Customs and Excise for the Year Ended March 31st. London: H.M. Stationery Office. 6*s.*

Accounts relating to trade and navigation of the United Kingdom for each month. London: H.M. Stationery Office, 12*s.* 6*d.*

The annual statement of trade of the United Kingdom. Vol. 1, 35*s.*; Vol. 2, 5*s.*; Vol. 3, 70*s.* London: H.M. Stationery Office.

Parliamentary debates (Hansard). London: H.M. Stationery Office.

House of Commons: Official Report London: H.M. Stationery Office.

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REVIEWS OF STATISTICAL AND ECONOMIC BOOKS

CONTENTS

	PAGE
1.—*Theil* (*H.*). Linear Aggregation of Economic Relations	363
2.—*Colerus* (*E.*). From Simple Numbers to the Calculus	364
3.—Rand Corporation. A Million Random Digits with 100,000 Normal Deviates	364
4.—National Bureau of Standards. Tables of Sine and Cosine Integrals for Arguments from 10 to 100; Table of the Gamma Function for Complex Arguments *Abdel-Aty* (*S. H.*). Tables of Generalized *K*-Statistics	365
5.—National Bureau of Standards. Computer Development (SEAC and DYSEAC) at the National Bureau of Standards	366
6.—*Cox* (*P. R.*). Addendum to Demography—Developments during 1949–54	367
7.—*Leibenstein* (*H.*). A Theory of Economic-Demographic Development	367
8.—Conference on Research in Income and Wealth. Short-term Economic Forecasting	368
9.—O.E.E.C. Sixth Report. From Recovery towards Economic Strength. Vol. I	369
10.—*Goldsmith* (*R. W.*). A Study of Saving in the United States. Vols. I and II	370
11.—*Prest* (*A. R.*) *and Stewart* (*I. G.*). The National Income of Nigeria, 1950–51	371

1.—*Linear Aggregation of Economic Relations*.. By H. Theil. Amsterdam: North-Holland Publishing Co., 1954. xi + 205 pp. $8\frac{1}{2}''$. 36*s*.

Much important work has recently been done in the estimation of aggregative economic relations. Though these relations have usually been formulated in close analogy with the demand and supply relations of the theory of individual choice, it has not been at all clear how the parameters which appear in them have been related to the corresponding parameters in the underlying micromodel. To take one obvious example: The incomes of many individuals—which will, of course, appear in the individual demand equation of the micromodel—may be more closely correlated with one of the price series appearing in an aggregative demand equation than with the total of personal disposable incomes which also appears therein. If so, would not the statistician impute to prices effects which were really due to income fluctuations; and would not the empirical relationship he found lack autonomy, depending as it would on the equations in the micromodel which determine the distribution of income? These are very old questions. Professor Theil has shown how they may be answered in an important class of models.

Briefly, he has proved that the coefficients of the aggregative equation will be weighted averages of all the coefficients in the corresponding micro-equations. The weights depend on the entire micromodel, and may therefore vary even if the sector in which we are interested remains unchanged, but they will always add up to one for the corresponding coefficients in the micro-equations and to zero for the non-corresponding coefficients. This is a great advance.

The following short proof of this—his central result—for the case of least squares estimators—may be of interest. It is, of course, less general than Professor Theil's own proof, which relates to all unbiased linear estimators.

Let $y^i = x\alpha^i + u^i$ be the demand equation for tomatoes of the ith household, where $y^i = \{y^i{}_t\}$, $x = [x^j{}_t]$ is a matrix of all the explanatory variables needed in any of the micro-equations, so that many of the elements of α^i will vanish, and u^i is a vector of random disturbances of the usual type. Then $y = x\alpha + u$ will be the total demand for tomatoes, where $y = \Sigma y^i$, $\alpha = \Sigma\alpha^i$, etc. Suppose, now, that the statistician, probably quite wrongly, postulates a relationship of the form $y = z\rho + v$, where $z^r = \underset{(r)}{\Sigma} x^j$, where (1), (2), . . . are disjoint subsets of the x's, those in (1) being the micro-variables corresponding to z^1 and so on. If then the regression of x^j on the z's is $x^j = \Sigma b_{jr} z_r + w^j$, it is easily seen that $\Sigma b_{jr} = 1$ if $r = s$, and 0 otherwise. Now the least squares estimator ρ^* of ρ is $(z'z)^{-1}z'y = \underset{(s)}{(z'z)^{-1}z'x}\alpha + (z'z)^{-1}z'u$. If, for want of a better definition, we define $\rho = E(\rho^*)$ we have $\rho = B\alpha$ where $B' = [b_{jr}]$ is the matrix of the regression coefficients of the x's on the z's. Hence, for instance, $\rho_1 = \underset{(1)}{\Sigma}\, b_{j1}\alpha^j + \underset{(2)}{\Sigma}\, b_{j1}\alpha^j + \ \ldots$, which is the result which we were to prove.

We note that it holds equally for aggregation over households, goods or time periods. It implies that the coefficients of a set of non-corresponding variables—e.g. those belonging to

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(2) above, may be important if they differ markedly among themselves, or if they are highly correlated with the corresponding regression coefficients (b_{j1}). It is easily shown that these difficulties can be completely avoided if, instead of straight sums, appropriated weighted averages are used—e.g. if individual incomes are weighted by the marginal propensity to consume tomatoes. However, the required weights will depend on the coefficients of the micromodel, and may render the aggregate in question uninteresting from every other point of view, save that of the equation in question.

Professor Theil also discusses the estimation of structural equations in a complete system. Here new difficulties arise, for the identifiability of the micromodel does not imply that of the macromodel, or vice versa. Moreover, even if the macromodel follows very closely the underlying micromodel, an overidentified macro-equation may imply narrow constraints on the micromodel. Finally, the use of weighted aggregates is much less helpful here than in the case of a single equation, for the weights which are appropriate to one part of the system may be inappropriate to another.

These are important advances in the theory of estimating macro-economic models. Yet they are only a few of the results reported in this excellent monograph, which should be in the hands of every econometrician.

W. M. GORMAN.

2.—*From Simple Numbers to the Calculus: Mathematics for Everyman.* By Egmont Colerus; translated by B. C. and H. F. Brookes. London: Heinemann, 1954 [i.e., May, 1955]. xi + 255 pp. 7″. 12*s.* 6*d.*

The author's preface ends "this book is an attempt to combat the general aversion to mathematics". The book thus sets out to reassure the reader who is a little scared of mathematical symbols, but sufficiently interested to want to discover what they are all about. It is one of the most successful popularizations that the reviewer has yet seen. The style is light and interesting, yet never merely frivolous; and it begins at the beginning, without assuming any previous knowledge. No detail is forgotten. From simple arithmetic the reader is gently led on to permutations and combinations, to algebra, analytical geometry, trigonometry, and differential and integral calculus. There are also chapters on scales of notation, indeterminate equations, Pythagoras's theorem and the binomial theorem. The translation is admirable, the illustrations well chosen and the diagrams very apt and clearly drawn.

One advantage of this book is that practically all the discussions are logically sound. The reader will have very little to unlearn on proceeding to more advanced works. Where the argument falls a little short of modern standards of rigour, the author is careful to point this out, explaining that he is only attempting a first introduction to the subject. There are occasional points where one may feel that the explanations are not quite so clear as they could be, but there are not serious defects, and the author would have to be more than human to avoid such weaknesses entirely. There are also occasional surprising statements, e.g. on p. 199 that "Pascal's triangle is of no use for negative exponents", although it can easily be extended to cover them.

It is a pity that there is no index.

The book is accordingly one to be recommended to those who need to learn some mathematics (as, for instance, students of elementary statistics) but who have forgotten what they learnt at school, or who were repelled by the subject. But it is only an introduction. Space does not permit more than a very brief excursion into each of the subjects covered, and by the time that the reader's appetite has been whetted, the author says "but we must press on". Clearly, to get lasting benefit from such a book, it must be followed by the reading of a good elementary textbook dealing with the subjects in greater detail.

CEDRIC A. B. SMITH.

3.—*A Million Random Digits with* 100,000 *Normal Deviates.* By the RAND Corporation. Glencoe (Ill.): The Free Press, 1955. xxv + 600 pp. 10½″. $10.00.

The book consists of 400 pages, containing one million decimal digits, and 200 pages containing 100,000 signed 3-decimal-place normal deviates. The latter are obtained as solutions x of

$$(D + \tfrac{1}{2})\,10^{-5} = (2\pi)^{-\frac{1}{2}} \int_{-\infty}^{x} \exp(-\tfrac{1}{2}t^2)\,dt\,,$$

where D runs through the 5-digit groups of the first 200 pages of decimal digits. The correspondence of D and x is maintained page by page, column by column, and line by line; hence the percentiles of the normal deviates are immediately available without recourse to a separate table of the normal integral. The 200 pages of normal deviates follow after the 400 pages of digits: a slightly more convenient arrangement would perhaps have been to interleave the 200 pages of normal deviates on the opposing pages to their corresponding pentads of random digits.

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Each page of random digits is arranged into 5 vertical blocks and 10 horizontal blocks. The resulting 50 intersections each consist of 2 columns of 5 lines of 5 digits. There are thus 2,500 digits per page. The reproduction is by photo-offset of the original IBM.856 Cardatype record; and is easy to read. The lines of the table are numbered for reference purposes from 00000 to 19999: unfortunately this numbering is in the same type as the tabular entries and not separated from them by a rule; so that a careless user may employ these reference numbers in the mistaken belief that they are random.

Each page of normal deviates is arranged in 10 vertical blocks and 10 horizontal blocks. The resulting 100 intersections each consist of 1 column of 5 lines of 1 deviate each. The sign of the deviate is printed after the 3rd decimal place. The lines are numbered 0000 to 9999 for reference, but are unlikely to be mistaken for deviates since they contain no decimal point.

The million random digits were produced in two stages. In the first stage the output was taken from an electronic 32-place roulette wheel, completing on the average about 3,000 revolutions between each trial. A binary-decimal converter discarded 12 of the 32 places and retained only the final decimal digit of the remaining 20 places. The outcome of this first stage showed significant deviations from uniform randomness. The second stage therefore comprised a rerandomization of the first, obtained by reducing (modulo 10) the sums of pairs of digits produced by the first stage.

The final table of one million digits was subjected to a battery of significance tests; namely (i) frequency tests of individual digits, (ii) poker tests of pentads, and (iii) serial and run tests of successive pairs and pentads. The corresponding random deviates underwent significance tests for (i) overall goodness-of-fit, (ii) goodness-of-fit in 1% tails, (iii) goodness-of-fit of sums of squares. The interpretation of such a battery of tests seems to the reviewer to be a fairly subjective matter; but he is inclined to suspect that the table is rather more uniform than it ought to be on "true randomness (if such a thing exists). In particularr the entry for $0{\cdot}50 > P > 0{\cdot}40$ in Table 2 (χ^2-test of poker hands) is noticeable; and, for the goodness of fit of the normal deviates, $\chi^2 = 346{\cdot}4$ with 399 degrees of freedom is rather low.

On page xxiv, $G_2(y/x)$ appears several times instead of $G_2(y \mid x)$.

The publication is opportune and a useful addition to the literature, since previous tables of random numbers have proved too small in certain Monte Carlo calculations. A footnote states that RAND has a table of Gaussian Markov chains with a discrete time parameter. There is a chain of 10,000 observations for each of the correlations $0{\cdot}600$, $0{\cdot}800$, $0{\cdot}900$, $0{\cdot}950$, $0{\cdot}970$, $0{\cdot}980$, $0{\cdot}990$, $0{\cdot}995$. There would be a good case for publishing this also.

J. M. HAMMERSLEY.

4.—*Tables of Sine and Cosine Integrals for Arguments from* 10 *to* 100. National Bureau of Standards Applied Mathematics Series, 32. Washington: Government Printing Office, 1954. xv + 187. 10″. $2.25.

—*Table of the Gamma Function for Complex Arguments.* National Bureau of Standards Applied Mathematics Series, 34. Washington: Government Printing Office, 1954. xvi + 105. 10″. $2.00.

—*Tables of Generalized k-Statistics.* By S. H. Abdel-Aty. New Statistical Table no. XIX. London: Biometrika Office, 1954. 8 pp. 10½″. 2*s*.

The first of these Tables is a re-issue in the Mathematics Series of the National Bureau of Standards of the tables first prepared by the New York Mathematical Tables Project, and published in 1942. The integrals $Si(x) = \int_0^x \sin u\, du/u$ and $Ci(x) = \int_\infty^x \cos u\, du/u$ are given for x lying between 10 and 100, at $0{\cdot}01$ intervals, to 10 decimal places. Tabulations for x below 10 appear in other volumes of the Series. Second central differences are given throughout, and are fully adequate for interpolation purposes due to the fine interval of tabulation. Auxiliary tables of $\frac{1}{2}p(1-p)$ and $p(1-p^2)/6$ are provided for use in interpolation with the Everett formula; multiples of $\frac{1}{2}\pi$ are also given.

Tables of these functions up to $x = 40$ appeared in 1931 in Vol. 1 of Mathematical Tables, published by the British Association for the Advancement of Science, but require more elaborate interpolation, so that the present extensive pair of tables fulfil a need. It is a little surprising to find that reference is only made to the second and third editions of the British Association tables, issued in 1946 and 1951 respectively. Other tables published by Tani in 1931 are also at fine intervals, and extend to $x = 50$, but give only 6 decimal places.

The second book of Tables, Series 34, is a new one, the computations for which have been in progress for many years. If $\log_e \Gamma(x + iy)$ be written $U + iV$, where $i = \sqrt{(-1)}$, then U and V

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are given, to 12 decimal places, for both x and y proceeding from 0 to 10 at intervals of 0·1. By the use of standard formulae it is shown that the effective range of x is from − 18 to 20, and of y from − 20 to 20, while an asymptotic expansion is provided for values outside this range. The properties of the Gamma Function are given briefly in an introduction which also explains the method of computation, and shows how both direct and inverse interpolation may be carried out by means of the Lagrangè-Hermite polynomial interpolation formula. A bibliography lists other tables of Gamma functions for complex arguments, and from this it is clear that no other table is anything like so extensive in its range as the new table, nor given to more than a few decimal places. The table is therefore extremely welcome, and will be very useful in many directions, not least in the fields of atomic and nuclear research. It is interpolable except in the neighbourhood of the origin, but no differences are provided, and some will consider it to be a little of a handicap that only one method of interpolation can conveniently be used. Anxiliary tables give $\sin \pi x$, $\cos \pi x$, $\sinh \pi x$ and $\cosh \pi x$ to 15 significant figures for x proceeding from 0 to 10 at intervals of 0·1.

The third table is a short one of 6 pages, reissued from Vol. 41 of *Biometrika*. It should be regarded as having a place among the five tables of symmetric functions computed and published by F. N. David and M. G. Kendall (in the same series of *Biometrika* tables), the difference being that in this case only the table for weight 12 need be given, since results for lower weights can easily be picked out from it. If generalized k-statistics are to have an accepted place in statistical theory, then there is no doubt that this table, which enables any generalized k (up to weight 12), to be written down at once in terms of the augmented symmetric functions of the sample observations, will be very useful. Inversely, the table also enables any augmented symmetric function (up to the same weight) to be expressed as a linear function of the generalized k's. Since a property of this statistic $k_{rst}\ldots$ is that its expectation in finite populations is the corresponding population statistic $K_{rst}\ldots$, or in infinite populations is the product $\kappa_r \kappa_s \kappa_t \ldots$ of population cumulants, it can be seen that we have a ready means of determining the cumulants, for example, of the multivariate distribution of the Fisher k-statistics in both infinite and finite population cases.

One misprint has been noted. The second column heading, which reads $k_2{}^{10}$, should be $k_{21}{}^{10}$.

J. WISHART.

5.—*Computer Development (SEAC and DYSEAC) at the National Bureau of Standards, Washington, D.C.* National Bureau of Standards Circular 551, Washington: Government Printing Office, 1955. iv + 146. 10″. $2.00.

There is a growing literature on the subject of the construction and operation of electronic calculators. This Circular is a bound book of some size, containing an Introduction by S. N. Alexander and eight separate articles by various authors. The object is to describe the Bureau's electronic computer programme, from its first beginnings in 1946, through the completion of SEAC (Standards Eastern Automatic Computer) in 1950, to the production of the second Bureau model known as DYSEAC. Throughout the language is somewhat severely technical, and uses the particular vocabulary which has grown up in this branch of scientific inquiry. It is thus not perhaps a book for the beginner, but it successfully accomplishes what it sets out to do, namely to give a full account, from the engineering point of view, of the computer programme of the Bureau. The SEAC is well known, and has been in continuous employment since its construction. No more need perhaps be said about it here, but a word or two about DYSEAC would not be out of place.

The object in constructing DYSEAC is to match the internal flexibility of machines of the general type (such as SEAC) with equally flexible means for keeping them in continuous communication with devices external to them. It follows that digital computers can be used with advantage both in control systems for industry and in information-processing systems for handling the mass paper work of business. All this is designed to speed up in industry and trade what is beginning to be called "automation" in this country, or what this book calls, by the American genius for inventing a longer word than the English, the automatization of industrial and commercial operations. The machine is mounted in a pair of vans, thus adding mobility to the other features of an automatic computer, and the most complete external feature to which it can be coupled is SEAC itself. There is a self-regulating property which will slow down the operations of the machine to match a slower-moving external programme, even to the extent of dealing with jobs which require considerable transfer of information into and out of the machine, or which involve searching through voluminous magnetic files. All this represents a trend which is understood to be a feature of machine construction in this country also, and so the details given will be of considerable interest to the expert.

J. WISHART.

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6.—*Addendum to Demography—Developments during* 1949–54. By Peter R. Cox. Cambridge University Press, 1955. viii+64 pp. 8½″. 5*s*.

When Cox's Demography first appeared in 1950 events in the field of population were moving fast; the first edition itself contained a short annexe to cover the salient features of the Report of the Royal Commission on Population. It has now been found necessary to issue a much larger supplementary booklet of 64 pages to cover the principal developments since 1949 at which time the earlier volume was still in draft. As this new booklet is strictly an addendum Mr. Cox has adopted the helpful device of numbering its sections to indicate the chapters in the main volume to which they relate.

A very good account is given of the arrangements for the 1951 Census and in particular of the basis and content of the one per cent. Sample Tables for Great Britain. A chapter on new developments in vital statistics covers the new consolidating Registration Act of 1953, a number of changes in publications of the Registrar-General and in particular the publication of more extended divorce statistics. New sources of morbidity statistics such as general practitioner records, hospital in-patient discharge studies, and cancer registration are critically reviewed. There is an interesting note of recent work in the analysis of mortality with special mention of the preliminary study of occupational mortality based upon the deaths of 1950.

Since the main volume was drafted there have been considerable developments in the analysis of statistics of fertility and marriage, and Mr. Cox has given an exceedingly succinct account of these, including the Family Census, which will be very helpful to the student. World population developments are not forgotten. There is also a note of recent population projections relating to Great Britain. An extensive bibliography at the end brings the student up to date with current literature. Altogether this small volume is a valuable addition to demographic reading.

B. BENJAMIN.

7.—*A Theory of Economic-Demographic Development*. By Harvey Leibenstein. Princeton University Press, 1954 (London: Geoffrey Cumberledge). xl + [ii] + 204 pp. 9″. 32*s*.

This book is, as its name implies, a theoretical essay. It is sometimes argued that the use of population statistics is less efficient for want of the support of rigorous theory. It is doubtful whether this is really true. Demography sometimes seems to suffer from a surfeit of new names for old ideas and new and less articulate substitutes for the older and simpler expressions of infinitesimal changes in a dynamic system of supply and demand. Moreover, the refusal of human beings to behave in accordance with mathematical requirements does not make life easier for the theorists. Against this somewhat cynical view it must be said at once that the limited application of a theoretical study is not necessarily a measure of its value. What is overridingly important is that population problems are multifactorial and cannot be understood without the use of analytical methods. If these methods provide the desired measure of comprehension the theorists have made a praiseworthy contribution. In these terms Professor Leibenstein's contribution is certainly praiseworthy.

The study is concerned with the central problem of transition from a condition of high birth-rates, high mortality (low expectation of life at birth) and low levels of average income, to a condition of low birth-rates, relatively low mortality and relatively high levels of average income. Professor Leibenstein calls this "for want of a better term" a transition from Malthusian to non-Malthusian conditions; but conflicting ideologies have played havoc with Malthus' name and the reader might be advised to stick to the problem without worrying too much about the label. The problem will be recognized as essentially that of the under-developed country upon which so much emphasis is now placed in the population field.

The technique adopted is to take a simple model at equilibrium in which average incomes are as low, and both fertility and mortality as high, as will allow the survival of the population; the population itself being as large as existing exploitation of resources will permit. An examination is then made of the changes which will disturb this equilibrium.

The economic conditions of initial equilibrium are that the income structure is of a "subsistence" character, inducing neither increase nor decrease in the population of any income group; a "subsistence" level being that at which net savings and investment are zero (interest rates must not disturb this equilibrium). The demographic aspects are equality between births and deaths, stable nuptiality and fertility, and stable occupational distribution. Underlying assumptions are that, controlling for other factors, it is possible to regard mortality and fertility as monotonic functions of average income—the one decreasing and the other increasing. The snag is that in these days of technical and economic assistance no economy is closed and these conditions are not those of practice. However, this does not detract from the value of the exercise as such.

An equilibrium displacement that increases average income also permits saving, increases capital resources per person, and increases average income still further; but this movement is

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opposed by the concomitant increase in population. Other displacements are also considered such as migration and innovations in the economy. The model begins to become more complicated; the problem more realistic.

The author draws the conclusion that an economy wishing to escape from the conditions initially defined must seek capital investment of a character which is labour-elastic, viz., such that with the new stock of capital the economy can absorb additional labour with a lesser sacrifice in average income than with the old (a transport system is an example).

The implications of the various displacements are pursued in relation to changes in income distribution and in age distributions and the effects of different patterns of population and investment shifts are analysed; useful numerical examples are given.

One advantage of the analysis is outstanding. In a world of tight interrelationships the practical administrator wants to know how much elbow room he has within which to achieve permanent improvement in economic development. His technical advisers will get a great deal of assistance from Professor Leibenstein.

B. BENJAMIN.

8.—*Short-Term Economic Forecasting*. Studies in Income and Wealth, Vol. 17, by the Conference on Research in Income and Wealth. Princeton: Princeton University Press, 1955. London, O.U.P. xi + 506 pp. 9″. 60*s*. net.

The student of pleonasm will find much of interest in this large and well-stocked book. A theme is early defined: "In this complex, dynamic world of ours, economic conditions are never the same." This is tenaciously developed with every variation, both in the pedestrian survey of forecasting methods by Bassie in the first paper and in the particular studies which follow. For example Hultgren feels obliged to end a short and interesting paper on "Forecasts of Railway Traffic": "The problem of forecasting freight movements is bound up with that of forecasting the general course of the economy"; and Firestone, in a discussion on "Investment Forecasting in Canada", rhetorically asks "who on the North American continent, for example, could have foreseen aggression in Korea, not only its occurrence, but also its timing . . .?" A firmer hand by editors of this series is now required together with a greater awareness by contributors that the reader can supply his own platitudes.

Yet there is much useful information and analysis here. Of particular interest are the papers on "Plant and Equipment Programs and their Realization" by Friend and Bronfenbrenner and the lengthy "Consumer Anticipations" by Lansing and Withey. In the first paper we are given an analysis of surveys recently carried out by the Office of Business Economics on the planned and actual capital outlays by businesses. Of 941 manufacturing firms which reported both figures for 1949 only one quarter came within 20 per cent. of their expected capital expenditures, while over one-fifth spent more than twice and one-tenth spent less than half the planned amounts. Nearly 60 per cent. of firms underestimated their outlays even though 1949 was "a year of moderate decline in economic activity" in which the same proportion of the sample overestimated their total sales. As regards sales forecasts Modigliani and Sauerlender report in another paper that (from 1927 to date) "respondents frequently failed to anticipate the direction of change, and even when they correctly anticipated the direction they seldom were able to gauge the full extent of the change". Similar results have been obtained from the Munich Business Test and by Ferber in his study of railroad shippers' forecasts.

These data stimulate the reader's interest in the distinction made by Cooper and Simon (pp. 352–9) between "rational" and "adaptive" behaviour. The latter is continually adjusted to events so that the organism gets along "well enough" in most situations, without maximizing any precise quantity, whereas the former is usually associated with a process of prediction and the maximization, say, of discounted expected gain. So those who incline to the analogy of servo-mechanisms in the theory of the firm will, I think, be confirmed in their beliefs by this book.

Similar findings are reported by Lansing and Withey and by Schweiger ("The Contribution of Consumer Anticipation in Forecasting Consumer Demand") in relation to the planning by consumers of their purchases of durable goods. Of those consumers who, at the beginning of 1948 and of 1949, stated that they would definitely buy a new car in the following twelve months, only one half did so. From an exhaustive study of these latter we find that 84 per cent. had incomes of $3000 or more in the previous year, the same or more in the current year, liquid assets of $1000 or more in the previous year and the same or more in the current year. Only 28 per cent. of the half who failed to carry out their intentions had the same favourable characteristics. Similarly many of those who bought without having expected to buy were found to have enjoyed unexpected improvements in their material conditions. So from the shifting sands of intentions we are forced to return to a study of external factors to explain realized purchases. The comments by Tobin (pp. 444–50) seem most apposite and thoughtful.

The analogy that springs to mind here is that of quantal bioassay. If a group of insects is

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given a 50 per cent. lethal dose, only one half die, but no doubt the other half feel very sick and would not give much for their chances if interviewed before the experiment. The usefulness to the demand analyst of the intentions survey is the insight it gives into consumer reactions and more particularly into the pattern of change of reaction to changes in external conditions. This insight will be most profitably used in constructing prediction systems in which the determining variables are objective in character.

J. A. C. BROWN.

9.—Sixth Report of the O.E.E.C., *From Recovery towards Economic Strength*. Vol. 1. Paris, March, 1955. London, H.M.S.O., 1955. 259 pp. $9\frac{1}{2}''$. 6*s*.

The tone of the Sixth Report of the O.E.E.C. published at the beginning of April reflects a condition of confidence and well-being.

At the beginning of 1955 production *per caput* in Western Europe was greater than ever before; the gold and dollar reserves of member countries as a whole were at their highest level since the war and a general dollar shortage was deemed unlikely in the near future. As the authors stress, "No previous annual report of the O.E.E.C. could describe so favourable a general situation. The progress already accomplished opens the way for further advance; and it inspires the confidence which makes such an advance feasible".

Looking backwards, the O.E.E.C. finds that, as compared with the pre-war year 1938 the volume of Western Europe's exports increased some 70 per cent. between 1938 and 1954, while the rise in imports was limited to 12 per cent. Industrial production rose by more than 50 per cent., agricultural production by about 30 per cent. Intra-European trade in 1953 was half again as large as in 1938 and in 1954 expanded by another 10 per cent. The authors observe that "the expansion of Western European production in 1953 and 1954 was the more remarkable in that it took place during a period of recession in the United States". They conclude that the inevitablity of a serious reaction in European activity from a slight American recession "was too easily accepted on the strength of the 1949 precedent".

The report contrasts the strong expansion in production in 1953 and 1954 with the stagnation in 1952. In 1953 industrial production in member countries increased by 5 per cent. and is provisionally estimated to have risen another 8 per cent. in 1954. The period since 1953 has been one of rising production and stable prices accompanied by outstanding relaxations in internal restrictions and controls.

Although in accordance with tradition the text of the O.E.E.C. report has been agreed by the Governments concerned, criticism has not been eschewed. Comparison is made between the increase in production of 15–20 per cent in Western Europe since pre-war with an increase of about double that rate in the United States and the main reasons for this difference are examined. The need to improve productivity in Western European industry and agriculture is regarded as the "pre-eminent problem of to-day".

The report notes the recent reappearance of signs of inflationary pressure but seems confident that even in those countries where resources are already fully employed and demand still rising this pressure can be held in check by "small but timely adjustments of policy".

American aid and military expenditure in Europe are examined and dissected and an optimistic view is taken of the outlook for Western Europe's trade and payments, despite the marked deterioration in the current balance of payments which developed in certain member countries in the latter part of the year.

The O.E.E.C. is convinced that the time is ripe for a new drive in the direction of liberalization and the substitution of open competition for government control.

"*Expansion* and *liberalization* are the two watchwords of European economic policy for the future. Experience shows how fruitful such a policy can be if vigorously pursued". A policy of internal expansion must be linked with one of liberalization, culminating in convertibility. Convertibility is discussed at considerable length not as something in the distant future, but as an acceleration of the movement already underway progressively to extend the liberalization of trade. "Convertibility is the technical expression of this movement towards freer international transactions". It is agreed that the task of removing the remaining obstacles to convertibility and of formulating world-wide rules for establishing it on a lasting basis will require closer international collaboration than exists to-day and global rather than regional organizations.

"The exact rôles which the appropriate international organizations would have to play, the division of responsibility and the liaison between them have not yet been determined".

R. GLENDAY.

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10.—*A Study of Saving in the United States.* By Raymond W. Goldsmith. Volume I: *Introduction—Tables of Annual Estimates of Saving* 1897 *to* 1949. xxx + 1,138 pp. Volume II: *Nature and Derivation of Annual Estimates of Saving* 1897 *to* 1949. xxiv + 632 pp. Princeton University Press, 1955. London, Geoffrey Cumberlege. 9½″. Vols. I and II together, 240*s.*

The importance of the complex rôle of saving in the macro-economic process has often been stressed and the results of Raymond Goldsmith's comprehensive study of the saving process in the United States have been anticipated with more than usual interest. These two large volumes contain the detailed statistical results of his inquiry. Their titles are a fair indication of their respective contents and, except in the introduction to Volume I which provides an analytical description of the results, they are confined to a detailed presentation of the estimates or to discussion of the concepts, raw materials and method involved in making the estimates. The analysis of the results is to be pursued in a third volume not yet published.

Within this limited frame of reference the material of the two volumes now published has been so systematically compiled and presented as to provide a model of empirical research technique. The statistics are set out and annotated in great detail in conformity with what the author calls the "principle of reproducibility"—that is to say with sufficient intermediate and explanatory data to enable the user to retrace the steps between the final estimates and the raw material. The basic definition of saving is a social accounting one, but to avoid the rigidity which might arise from conformity to a single definition, the author has developed a series of variant concepts, each of which fits into a system of social accounts but each of which can be adapted to different analytical purposes. The estimates are calculated on a period (quadrennial) basis as well as on an annual basis.

Part of the cost of these high standards of statistical procedure is reflected in the sheer physical bulk of the two volumes. To reduce the disadvantages of size the author has provided detailed tables of contents or lists of tables and frequent summaries and signposts throughout the text in addition to separate bibliographies and indices for each volume. Text and tables are apparently exhaustive. The reviewer, staggering under the impact of more than 700 pages of text and more than 1,000 pages of tables and notes is left with the impression that none of the statistics of the inquiry are missing and that nothing has been left unsaid about the estimates. Much indeed has been said twice and even more than twice. But the proof of this kind of pudding is not in the eating but in the digestion, and it must be left to those who make practical or analytical use of Mr. Goldsmith's estimates to assess the exhaustiveness of his presentation.

The method of estimate is "by the aggregative balance sheet method". Estimates of different forms of saving for each saver group (individuals, farmers, unincorporated enterprise, corporations, and local, state and federal government) are built up from aggregative series. Sample household saving inquiries were, however, used extensively as checks and to provide information not available in aggregative form, e.g. information relating household saving to income levels. Margins of error are discussed at length and the general conclusion (Vol. II, p. 14) is that "the probable error for any one year in the estimate of total national saving, within the definitions used in this study, cannot be expected to be less than 10 per cent. and is not likely to be above 30 per cent. disregarding sign, and that the boundaries may well be as narrow as 15 to 25 per cent. For groups of subsequent years the error is somewhat lower, possibly declining to the neighbourhood of 10 per cent. for periods of over five years".

Perhaps the most interesting general feature of Mr. Goldsmith's results is the evidence they provide of a remarkable stability of aggregate savings behaviour in the long-term in spite of the extreme short-term variability in national savings. After adjusting for changes in prices and population the volume of United States saving (including consumer durables but excluding military durables) has shown an upward secular trend of approximately 1¾ per cent. a year over the last half century. Over the same period the short-term cyclical fluctuations have been such that "one year's national saving has in at least one half of the cases been 50 per cent. higher or lower than that of the preceding or the following year" (Vol. I, p. 5). There appears to be little secular trend in the distribution of national saving among the main saver groups or in the proportion of income saved by them although cyclical fluctuations are considerable.

In a brief analysis of some of the econometric implications of his results Mr. Goldsmith finds that changes in current income are the most important single determinant of variations in current national and personal saving. He also finds that saving has tended to absorb a lower proportion of real income throughout the last half century and that the marginal propensity to save has not been constant. Among the tentative conclusions which he draws from his econometric analysis is that "the formula for a long-term function for the saving ratio should contain at least two components, the first a constant and the second a cyclical factor depending on something like the ratio of actual to full employment income" (Vol. I, p. 14).

In conclusion it may be said that these two volumes are essentially a work of basic statistical reference, destined to become the standard authority in this field. As a consequence of Mr.

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Goldsmith's comprehensive approach to his problems, however, they are likely to interest a wider group of economists and statisticians than the actual users of his statistics. Methodological and technical problems of making savings estimates are discussed at length, for example, and the introductory analysis, tentative though it is, provides a convenient introduction to the theoretical study of savings behaviour. The result is a useful text book on the study of national saving.

P. M. DEANE.

11.—*The National Income of Nigeria* 1950–51. By A. R. Prest and I. G. Stewart. (Colonial Research Studies No. 11), London: H.M. Stationery Office, 1953. viii + 123 pp. 9½″. 8*s.* 6*d.*

This Report fulfills a task entrusted to the Department of Applied Economics of the University of Cambridge by the Nigerian Government and the Colonial Office, in conjunction with the Colonial Economic Research Committee. The authors have presented a Report which, as Professor Robinson rightly claims in the Foreword, is of great significance and interest.

The income of Nigeria is calculated as far as possible through the "output approach", the "expenditure approach" and the "income approach", and there follows an attempted reconciliation between these. Sections are devoted to the Government accounts, Capital Formation and the Balance of Payments; and to a calculation of the incomes of the regions. There is also a discussion of basic theoretical concepts, and, finally, some valuable suggestions for further work are made.

Although making for neatness in presentation, I am not convinced that the threefold output, expenditure, income approach, is as yet warranted in regular National income calculations by Government Departments in territories like Nigeria. As the authors state (p. 54): "Ideally the income total should be derived from entirely distinct sources from the output total. . . . ". In Nigeria however, this "is still a dream". In the expenditure approach the estimates in respect of home produced goods are also not from sources sufficiently independent of each other to lead to much, if any, increased statistical accuracy.

The authors draw attention to the fact (p. 21) that "National Budgeting on the lines developed over the last few years in the U.K., is quite inapplicable in Nigerian conditions". It would therefore have been useful if they had also constructed a single simplified account.

After posing the very relevant question: "if it had been possible to set out the social accounts of eighteenth century England (and it is highly significant that accounting only matured *after* the Industrial Revolution) would the governing statesmen *of that time* have been able to place their economic policy on a sounder basis or direct affairs with a surer hand?", the authors state: "The answer surely is unequivocal. Where complex economic transactions do not exist, little purpose is served by making them appear to do so" (p. 21).

Yet, in attempting with much ingenuity to overcome the well known difficulties which arise from the isolation of subsistence producers from the market, or from the money economy or from both, they appear to have made the simple unduly complex merely in order to evaluate it. Instead of accepting the fact that what it is most important to discover is the extent to which Nigeria is moving out of the production pattern of the eighteenth or earlier centuries into that of the modern world, they have chosen to impute money values to all subsistence activities, including activities which involve services from one member of the family to another.

The authors allege that (p. 9) "it is frequently argued that non-cash activity is in some sense or other fundamentally different from cash transactions and that no attempt should be made to value it or, if any attempt is made, it should be carefully segregated from the total of money transactions".* But the question at issue is not the character of the activity but whether the activity can be evaluated meaningfully in money terms. Is it meaningful to be told by the authors that the minimal valuation of housewives' services in the United Kingdom today would probably be £1,000m; or that the self-services of driving one's own car might well be in the £100 to £200m. range (p. 9)? The thousands of non-motorists anxious to obtain motor-cars would, I fear, be surprised to be told that they should be happy without them because they are not put to the exertion of driving them.

In the authors' view, omission or separation of subsistence activity cannot possibly be justified in the case of Nigeria. Moreover, they contend (p. 8) that "if we are to make a *complete* assessment of all productive activities inside a country, then it is clearly irrelevant whether these are performed for oneself, for other members of the family or for outsiders". In my opinion these views are erroneous because services which the individual performs for himself or for others within the family or within a non-market economy are in fact not evaluated in money terms, and any money values imputed to them are quite arbitrary. If a statistical observer says that the National Income of a

* In this connection they refer to, but I believe have misunderstood, my observations on this question, in 'Concepts of Income and Welfare in Advanced and Under-developed Societies', (Income and Wealth Series III) now reprinted in an expanded form in *The Economic Impact on Under-developed Societies*, Blackwells, 1953.

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tribe of pygmies living in a subsistence economy deep in the forest and isolated from all outside contacts is equivalent to £1, £2 or £100m., I would not object to his doing so, but I doubt if such imputations tell me anything useful. What is really important for statistical evaluation is that when production takes place for the market in exchange for money (as it must do if it is ever to increase appreciably), the evaluation is determined not by the observer but by the market—and it is these evaluations which alone have some objective meaning. When, on the contrary, following the method of the authors, one goes to the lengths of evaluating the work done by wives in Nigeria on the basis of the bride price which is paid for them (in itself a misunderstanding of the nature and significance of bride price) statistical imputation becomes farcical.

The confusion into which the authors have been led is shown by the discussion (pp. 13–14) of the difficulties of calculating the output of a village assumed to be *entirely* on a self-subsistence basis. "Then", the authors write, "it is conceivable that the expenses of transporting to the nearest market are greater than the prices prevailing in that market. This would imply a *negative* income for the unfortunate village." And they suggest that "a similar situation in respect of any one activity is perfectly possible". They take, for example, a village where everyone carries his (or her) own family water from wells, whereas, in the town a few miles away water sells for ½d. a pail. As the costs of carrying water from the village to the town might easily be 6d. a pail, they ask "Is the contribution to National Output of a pail of water drawn in this village to be regarded as minus 5½d.?". The point here is that there is no *national* output because by hypothesis the village activity or water-drawing is entirely isolated. There is a village output—but since there is no objective price mechanism through which the activities are evaluated it is anybody's guess what the village output is worth—and what that guess may be is quite irrelevant to our calculations of the *national* output—since by hypothesis no national markets or division of labour exist. For similar reasons I can see little advantage in valuing imputed food consumption at retail prices, a procedure which is even more arbitrary than the unavoidable one of utilising farm prices which is usually adopted once it has been decided to impute values to subsistence production.

By concentrating unduly on the problems of evaluating subsistence production the authors have omitted to give us on a separate basis information on output and services sold and priced in the growing modern export and local markets of Nigeria. Unfortunately, this valuable report does not adequately disclose how the economic revolution in Nigeria is proceeding, and those using it cannot always be sure that some of the totals which are presented are not the result of purely statistical imputations of doubtful validity.

S. Herbert Frankel.

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STATISTICAL NOTES

(1) British Official Statistics

The interim index of retail prices published by the Ministry of Labour and National Service which was 146 in March rose to 147 in April and May (prices at June 17th, 1947 = 100). There were increases in April and May in the prices of some vegetables and fruit and fish, and of electricity. These were partly offset, however, by reductions in the prices of tea and bacon and by a seasonal decline in the price of household coal. Separate figures on the same basis (i.e. June, 1947 = 100) are not available for the different groups of commodities, but the following are the figures based on January 15th, 1952 = 100.

Date	*Food*	*Rent and Rates*	*Clothing*	*Fuel and Light*	*Household Durable Goods*	*Miscellaneous Goods*	*Services*	*Alcoholic Drinks*	*Tobacco*	*All Items*
Weights:	399	72	98	66	72	44	91	78	90	1,000
March 15th, 1955	118·6	113·9	96·3	114·8	95·4	99·7	113·2	102·5	100·3	110·2
April 19th, 1955	119·9	114·4	96·3	114·8	95·5	99·9	113·5	102·7	100·3	110·8
May 17th, 1955	119·8	114·7	96·2	111·4	95·6	101·4	113·9	102·7	100·3	110·6

The Ministry of Labour index of weekly wage rates, which was 149 in March (June 30th, 1947 = 100) rose to 152 in April and May. The principal classes of workers whose rates of wages were increased during the period included building and civil engineering workers, coal miners, local authority employees, gas workers, dock workers, and employees in furniture making unlicensed places of refreshment and boot and shoe manufacture.

The total working population and the numbers in civil employment in the three months ended April, 1955, were as follows:

(*Thousands*)

	Total Working Population			*Numbers in Civil Employment*		
	Males	*Females*	*Total*	*Males*	*Females*	*Total*
Feb., 1955 . .	16,072	7,761	23,833	15,082	7,644	22,726
March, 1955 . .	16,052	7,748	23,800	15,090	7,642	22,732
April, 1955 . .	16,060	7,776	23,836	15,128	7,679	22,807

The number of persons on the unemployment registers of the Employment Exchanges in Great Britain fell by nearly 10,000 in April and by a further 36,500 in May. The total of 223,643 in May, 1955, represented 1·0 per cent. of the estimated total of employees. The percentage in the different Regions ranged from 0·5 in the Midlands and North Midlands to 1·7 in the Northern Counties and Wales and 2·2 in Scotland.

The following is a sex analysis of the figures:

	Number of Unemployed Persons on the Registers of Employment Exchanges		
Date	*Men and Boys*	*Women and Girls*	*Total*
March 14th, 1955 . . .	173,615	96,296	269,911
April 18th, 1955 . . .	167,584	92,545	260,129
May 16th, 1955 . . .	136,226	87,417	223,643

Of the total of 223,643 in May, 60,648 had been unemployed for not more than two weeks, 45,269 for two to eight weeks, and 92,890 for more than eight weeks, while 24,836 were temporarily stopped.

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The numbers of insured persons absent from work owing to sickness, including self-employed as well as employed, were 1,062,600 in March, 936,600 in April and 876,700 in May. The numbers of employed persons absent owing to industrial injuries were 62,200, 54,900 and 57,200.

Final figures became available in May of the effect of industrial disputes in the year 1954. These showed that there were 1,989 stoppages of work, of which 1,464 were in coal mining. The number of workers involved was 450,000 (204,400 in coal mining) and the number of working days lost was 2,457,000 (468,000 in coal mining). An industrial analysis shows that 521,000 days were lost in shipbuilding and repairing and 787,000 in dock labour. The total of 2,457,000 days lost was the heaviest since 1945 and compares with an average of 1,982,000 over the last 20 years. It is, however, lower than the figure for still earlier years. In 1914–1918 the average was 5,360,000, and from 1919 to 1921, the average was 49,140,000. In the following 10 years the average was 7,560,000, omitting 1926 when 162,000,000 days were lost in the general strike and in coal mining. In the first five months of 1955 401,500 workers were involved in stoppages causing a loss of 1,427,000 working days.

The *Ministry of Labour Gazette* for June, 1955, contains an age analysis of the employee population in Great Britain in May, 1954. Of the total of 13,840,000 males 180,000 were 70 and over and 541,000 were 65 and over. Amongst 7,350,000 females 38,000 were 70 and over and 120,000 were 65 and over. Figures relating to married women showed a total of 3,370,000, or 46 per cent. of the total number of female employees. The number had increased by 120,000 in a year, mainly in the age groups 40 and over. The review also contains regional and industrial analyses of the figures and some estimates of inter-regional migration.

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(2) Other Statistics

The United Nations Educational Scientific and Cultural Organization has recently produced a summary of its national reports on the University Teaching of Sociology, Social Psychology and Social Anthropology, *The University Teaching of the Social Sciences, Sociology, Social Psychology and Anthropology* (London: H.M.S.O., 1954, pp. 252, 10*s.* 6*d.*). The countries covered are: Western Germany, Australia, Egypt, the United States of America, France, Great Britain, India, Mexico, Poland and Sweden. A factual survey of the teaching arrangements in each of these countries is given, though in some instances this is already out of date. Professor de Bie writes a general introduction and there are specialized reports on Social Anthropology and Social Psychology.

It is, of course, difficult to summarize and distil the trends in teaching of countries with very different traditions in the field of the social sciences. The most interesting paper in the report, however, is Professor Lévi-Strauss's discussion of the place of Anthropology in the Social Sciences, which deals with much more general problems than the rest of the chapters.

A new edition of a work published in 1949, *Die Geschichte der Arbeiter in England, Part I,* 1640–1760, *Part II,* 1760–1832 by J. Kuczynski (Berlin, 1954) has recently appeared. The first part describes the rise of "capitalist England in the 17th and 18th centuries"; the second is a description of the industrial revolution and of the state of the working-classes, to which is added a summary of the classical bourgeois economics of Adam Smith and David Ricardo. References are given for most of the facts and there is an extensive bibliography appended to the first part. The general tone of the work can be judged from the fact that it is dedicated to the Academy of Science of the U.S.S.R. for its "resolute struggle against reaction" and that the authors most frequently quoted are Karl Marx and Frederick Engels.

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CURRENT NOTE

The Trustees of the Houblon-Norman Fund, on the recommendation of their Advisory Committee, have made the following awards for 1955–56.

Research Grants.—Mr. G. Clayton, Lecturer, University of Liverpool (Renewal), "The Present Organization and Structure of the Swedish Banking System"; Mr. Ralph Davis, Lecturer, University of Hull, "The Organization and Finance of the English Shipping Industry, 1660–1702"; Mrs. C. R. Fulop, Lecturer, "The Economics of the Buying Practices of Retailers"; Mr. E. L. Furness, Lecturer, Glasgow Commercial College, "20th Century Development of Scottish Banking"; Mr. R. E. George, Statistical and Administrative Assistant, South Western Gas Board (Renewal) "Economic Policy in the Gas Industry before Nationalisation"; Miss D. M. Knox, History Mistress, Ursuline Convent, Brentwood (Renewal), "London Brewing Trade 1830–1914"; Mr. R. V. Lennard, Historian (Renewal), "Rural England in the Feudal Age"; Mr. G. J. de C. Mead, Bank of England, "The Intendants of 18th Century France"; Mr. A. L. Minkes, Tutor, Department of Extra-Mural Studies, University of Birmingham, "The Economic Structure and Problems of the British Paint and Varnish Industry"; Mr. R. G. Opie, Lecturer, London School of Economics, "Techniques of Central Banking Control in the Federal Republic of Germany"; Mr. R. A. C. Parker, Lecturer, University of Manchester, "18th and Early 19th Century Landed Estates"; Mr. H. W. Parris, W.E.A. Tutor, Northamptonshire, "Board of Trade Railway Department and its Influence on the Development of the Railway System in Great Britain"; Mr. R. J. Pounce, Research Officer, Board of Trade, "Post-War Unemployment in Great Britain"; Mr. C. N. Ward-Perkins, Fellow of Pembroke College, Oxford, "An Index of Country Banks in England and Wales; Mr. A. A. Zukowski, formerly Scientific Assistant, Commonwealth Forestry Bureau, Oxford, "Forest Policy of England in relation to her Economic Development."

An offer of awards for 1956–57 will be made in due course. Further information may be obtained from the Secretary, Houblon-Norman Fund, c/o Bank of England, London, E.C.2.

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STATISTICAL AND ECONOMIC ARTICLES IN RECENT PERIODICALS

UNITED KINGDOM—

Biometrika—

June 1955—Studies in the history of probability and statistics. I. Dicing and gaming (a note on the history of probability): *F. N. David.* Some features of the generation times of individual bacteria: *E. O. Powell.* Quantum hypotheses: *S. R. Broadbent.* The truncated negative binomial distribution: *M. R. Sampford.* The randomization analysis of a generalized randomized block design: *M. B. Wilk.* Some quick sign tests for trend in location and dispersion: *D. R. Cox* and *A. Stuart.* The variance of the maximum of partial sums of a finite number of independent normal variates: *A. A. Anis.* Spatial point processes, with applications to ecology: *H. R. Thompson.* The outcome of a stochastic epidemic—a note on Bailey's paper: *P. Whittle.* A note on Bailey's and Whittle's treatment of a general stochastic epidemic: *F. G. Foster.* The deterministic model of a simple epidemic for more than one community: *S. Rushton* and *A. J. Mautner.* Exact tests for serial correlation: *E. J. Hannan.* On the efficiency of procedures for smoothing periodograms from time series with continuous spectra: *M. S. Bartlett* and *J. Medhi.* The autocorrelation function and the spectral density function: *J. Wise.* Sampling properties of local statistics in stationary stochastic series: *G. H. Jowett.* Models for two-dimensional stationary stochastic processes: *V. Heine.* Some problems in the theory of provisioning and of dams: *J. Gani.* Approximate confidence intervals. III. A bias correction: *M. S. Bartlett.* The theory of correlation between two continuous variables when one is dichotomized: *R. F. Tate.* The normal probability function: Tables of certain area-ordinate ratios and of their reciprocals: *Editorial.* Tables of symmetric functions. Part V: *F. N. David* and *M. G. Kendall.* Control charts with warning lines: *E. S. Page.* Approximations to the probability integral and certain percentage points of a multivariate analogue of Student's *t*-distribution: *C. W. Dunnett* and *M. Sobel.* Galton's rank-order test: *J. L. Hodges, Jr.* On bounds for the normal integral: *J. T. Chu.* Substitutes for χ^2: *J. B. S. Haldane.* A problem in the significance of small numbers: *J. B. S. Haldane.* Bounds for the ratio of range to standard deviation: *G. W. Thomson.* On the estimation of population parameters from marked members: *J. A. Gulland.*

Cambridge Philosophical Society, Proceedings—

January 1955—The central limit theorem for *m*-dependent variables: *P. H. Diananda.* A note on recurrent events: *V. N. Patankar.*

April 1955—On games with almost complete information: *B. J. Birch.* A use of complex probabilities in the theory of stochastic processes: *D. R. Cox.*

Economica—

May 1955—The accountant's contribution to the trade cycle: *W. T. Baxter.* The transfer problem: a note on the criteria for changes in the terms of trade: *H. G. Johnson.* The engineer's approach to economic models: *R. G. D. Allen.*

Eugenics Review—

April 1955—Demographic developments in Great Britain since the Royal Commission on Population: *P. Cox.*

Incorporated Statistician—

April 1955—Some estimation problems in demand analysis: *R. Stone, J. Aitchison* and *J. A. C. Brown.* Labour turnover: *A. J. H. Morrell.* Raw cotton statistics: *R. Robson.* Statistical methods in chemical process development: *D. R. Read.*

Journal of Agricultural Economics—

February 1955—The "production functions" for the average and marginal productivity of land and labour in English agriculture: *Colin Clark* and *J. O. Jones.* The effect on net income of changes in the volume and prices of output and input: *F. Holme.*

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Operational Research Quarterly

December 1954—Application of birth and death process to provision of spare machines: *J. Taylor* and *R. R. P. Jackson.* Queueing systems with phase type service: *R. R. P. Jackson.*

March 1955—Measurement and management: *O. H. Wansbrough-Jones.* The accuracy and use of time study. The uses and abuses of analogy: *Vera Daniel.*

Oxford Economic Papers (New Series)—

February 1955—Some implication of the growth of investment by institutions, 1938–53: *R. Frost.* The valuation of net investment: *C. Kennedy.* Retailing costs: some comments on the Census of Distribution, 1950: *S. Pollard* and *J. D. Hughes.*

Oxford University Institute of Statistics, Bulletin—

February 1955—Growth and the balance of payments: a symposium. Articles by *H. G. Johnson, P. Streeten, J. R. Sargent, R. L. Marris, D. Seers, R. Nurkse, C. Kennedy, W. A. Lewis, N. H. Leyland, G. D. N. Worswick* and *P. D. Henderson.*

Review of Economic Studies—

Vol. XXII (2), No. 58—The saving function and the problem of trend and cycle: *R. C. O. Matthews.* Some problems in the estimation of personal savings and investment: *C. T. Saunders.*

Society for Psychical Research, Journal—

June 1955—Randomness: the background, and some new investigations: *J. F. Nicol.*

UNITED STATES—

American Statistical Association, Journal—

March 1955—Canada—northern neighbor: *H. Marshall.* The population of the United States in 1950 classified by age, sex, and color: *A. J. Coale.* A structure of moneyflows: *M. Mendelson.* The measurement of seasonal movements in price and quantity indexes: *B. D. Mudgett:* An application of Markov processes to the study of the epidemiology of mental disease: *A. W. Marshall* and *H. Golhamer.* Maximum likelihood and minimum χ^2 estimates of the logistic function: *J. Berkson.* Some statistical problems in relating experimental data to predicting performance of a production process: *T. W. Anderson.* Some minimum cost experimental procedures in quadratic regression: *A. de la Garza, D. S. Hawxhurst* and *L. T. Newman.* Tables of percentage points for the studentized maximum absolute deviate in normal samples: *M. Halperin, S. W. Greenhouse, J. Cornfield,* and *J. Zalokar.* Estimation of the parameters of a skewed distribution by linear systematic statistics: *A. E. Sarhan.* A family of J-shaped frequency functions: *C. W. Topp* and *F. C. Leone.* Basic problems, techniques, and theory of isopleth mapping: *C. F. Schmid* and *E. H. MacCannell.*

American Statistician—

April 1955—The financial and membership status of the American Statistical Association: *S. Weiss* and *A. Rothman.* In defense of frequencies: *J. E. French* and *I. Miller.* Instruction in statistics in the colleges and universities of the south: *H. H. Chapman.*

Annals of Mathematical Statistics—

March 1955—The Cramér-Smirnov Test in the parametric case: *D. A. Darling.* Characterizations of complete classes of tests of some multiparametric hypotheses, with applications to likelihood ratio tests: *A. Birnbaum.* Asymptotic solutions of the compound decision problem for two completely specified distributions: *J. Hannan* and *H. Robbins.* The efficiency of tests: *W. Hoeffding* and *J. R. Rosenblatt.* On a theorem of Pitman: *G. E. Noether.* An extension of Wald's theory of statistical decision functions: *L. LeCam.* Sequential life tests in the exponential case: *B. Epstein* and *M. Sobel.* Rank sum tests of fit: *C. I. Tsao.* Random functions satisfying certain linear relations, II: *S. G. Ghurye.* On the distribution of the sample median: *J. T. Chu.* Some new test criteria in multivariate analysis: *K. C. S. Pillai.* Distribution of definite and of indefinite quadratic forms: *J. Gurland.* Note on the distribution of a definite quadratic form: *J. Pachares.*

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On the maximum number of constraints of an orthogonal array: *E. Seiden.* On a sequential test for the general linear hypotheses: *P. G. Hoel.* Two comments on "Sufficiency and statistical decision functions": *R. R. Bahadur* and *E. L. Lehmann.* A note on confidence sets for random variables: *L. Weiss.* An inconsistency of the method of maximum likelihood: *D. Basu.* A note on simultaneous confidence intervals: *M. Dwass.* An inequality on Poisson probabilities: *H. Teicher.* Note on linear hypotheses with prescribed matrix of normal equations: *J. E. Maxfield* and *R. S. Gardner.*

Biometrics—

March 1955—Multiple range and multiple *F*-tests: *D. B. Duncan.* Further contributions to the theory of paired comparisons: *M. G. Kendall.* Comparative sensitivity of pair and triad flavor: *J. W. Hopkins* and *N. T. Gridgeman.* Quantitative studies in diphtheria prophylaxis: an attempt to derive a mathematical characterization of the antigenicity of diphtheria prophylactic: *L. B. Holt.* Determining the fruit count on a tree by randomized branch sampling: *R. J. Jessen.*

Econometrica—

April 1955—The life cycle in income, saving, and asset ownership: *H. Lydall.* A note on the statistical discrepancy in the national accounts: *A. J. Gartaganis* and *A. S. Goldberger.* Upper bounds, secondary constraints, and block triangularity in linear programming: *G. B. Dantzig.* Recent experiences with the Munich business test (an expository article): *H. Theil.*

Harvard Business Review—

March-April 1955—Electronic computers: a progress report: *P. B. Laubach* and *L. E. Thompson.*

Industrial Quality Control—

April 1955—Attaining uniformity in processing rubber barches: *P. E. Gnaedinger.* The rôle of a biometrician in the pharmaceutical industry: *C. I. Bliss.* Perception, preference, judgment—clues to food quality: *D. R. Peryam* and *R. Shapiro.*

May 1955—The impact of quality control on retail merchandising: *E. Freeman.* Probability statistics in accounting: *A. C. Rosander.*

Operations Research Society of America, Journal—

May 1955—The competence and limitations of scientific method: *H. Margenau.* The influence of vehicular speed and spacing on tunnel capacity: *E. S. Olcott.* Direct use of extremal principles in solving certain optimizing problems involving inequalities: *B. Klein.* Mathematical models for freely-flowing highway traffic: *G. F. Newell.* The use of storage water in a hydroelectric system: *J. D. C. Little.* The Poisson distribution as a limit for dependent binomial events with unequal probabilities: *J. E. Walsh.* On the numerical solution of the transportation problem: *H. S. Houthakker.*

Review of Economics and Statistics—

May 1955—American productivity and the dollar payments problem: *E. M. Bernstein.* Soviet heavy industry: a dollar index of output, 1927/28–1937: *A. Gerschenkron.* More on the misuse of mathematics in economics: a rejoinder: *S. Enke.* The accuracy of aggregate savings functions in the post-war years: *R. Ferber.* A study in redistribution and consumption: *M. Bronfenbrenner, T. Yamane,* and *C. H. Lee.* The multiplier effects of redistributive public budgets: *A. H. Conrad.* The symposium on statistical sources in the United Kingdom: *D. Seers.* Some notes on population and living levels: *H. H. Villard.*

FRANCE—

Journal de la Société de Statistique de Paris—

October-December 1954—L'Organisation du contrôle statistique aux États-Unis: *R. Hénon, P. Delaporte* and *P-H. Ferignac.*

Revue d'Économie Politique—

March–April 1955—La théorie des jeux: *G. Th. Guilbaud.* Remarques sur le niveau de la production manufacturière de la France: *H. d'Herouille.*

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GERMANY—

Allgemeines Statistisches Archiv—

Vol. 38, Part 4—Grundsätliches zur repräsentativen Erfassung des Familieneinkommes: *H. Schmucker.* Techniken der Befragtenauswahl bei der Anwendung des zufallsgesteuerten Stichprobenverfahrens in der Marktforschung: *H. Löchner.* Über das Interviewerverhalten bei der Befragtenauswahl nach verschiedenen üblichen Auswahlvorschriften: *K. F. Flockenhaus.*

Mitteilungsblatt für Mathematische Statistik—

Vol. 7, Part 1—Signifikanzuntersuchungen der einfachen Struktur in der Faktorenanalyse: *R. Bargmann.* Die LEXISsche Dispersionstheorie in ihren Beziehungen zur modernen statistischen Methodenlehre, insbesondere zur Streuungsanalyse (analysis of variance): *R. K. Bauer.* Ein Kriterium für zwei Typen zweidimensionaler Normalverteilungen: *P. Ihm.* Technische Ermittlungsverfahren im Dienste der Hörer-Meinungsforschung: *R. Oerding.* Fehlerabschätzung zum Binomialpapier von Mosteller-Tuckey: *B. Wiezorke.* Über ein Zählverfahren zur Bestimmung von Mittelwert und Streuung: *B. Wiezorke.*

Weltwirtschaftliches Archiv—

Vol. 74, Part 1—*Per capita* rate of economic growth: *A. Y. C. Koo.* British balance of payments policy 1946–1950: *F. Gehrels.* Die Nachfrage nach Butter: *H. Gollnick.* A quantitative determination of the importance of the shipping industry in the economy of Western Europe: *J. O. Norbom.*

ITALY

Rivista Italiana di Economia Demografia e Statistica—

January–June 1954—Su alcune applicazioni dei metodi di eliminazione nelle ricerche sperimentali: *G. Pompilj.* Bertillon e Gumplowicz. Considerazioni sociologiche sulle diminuzioni delle nascite in Francia: *F. Savorgnan.* Di alcuni criteri metodologici per la ripartizione del reddito nazionale fra le regioni d'Italia: *G. Cusimano.*

Statistica—

January–March 1955—I valori mediani in una distribuzione continua: *C. Bonferroni.* Contributo allo studio delle serie cicliche: *V. Castellano.* Nozioni introduttive allo studio di alcuni aspetti della significatività statistica: *S. Vianelli.* Gli indici di connessione nel caso di variabili casuali normali e considerazioni sulla graduatoria tra indici di connessione e indici concordanza: *T. Salvemini.* Contributo alle ricerche sulla dispersione delle variazioni dei prezzi: *M. Saibante.* Della diffusione dell'istruzione in alcune provincie italiane: *A. de Polzer.* Cause di morte mal definite nella statistica italiana: *S. Somogyi.* Ricerche sperimentali intorno alle relazioni tra popolosità e movimento naturale della popolazione: *I. Scardovi.* Schema di graduazione, misure di variabilità e valori medi: *P. Fortunati.*

SWITZERLAND—

Mitteilungen de Vereinigung schweizerischer Versicherungsmathematiker—

Vol. 55, Part 2—Das Erneuerungsproblem und seine Erweiterung auf stochastische Prozesse: *H. Ammeter.* Evolution récente de la théorie mathématique sur la distribution des revenus: *E. Kaiser.*

INTERNATIONAL—

International Labour Review—

March 1955—The Eighth International Conference of Labour Statisticians.

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LIST OF ADDITIONS TO THE LIBRARY

Since the issue of Part II, 1955, the Society has received the publications enumerated below.

I.—OFFICIAL PUBLICATIONS

United Kingdom. *Commonwealth Economic Committee.* Commonwealth agriculture: a memorandum on production, prices and trade. London. H.M.S.O., 1955. 9¾″. 2*s.* 6*d.*

General Register Office. Census 1951 England and Wales: County report ... Anglesey and Caernarvonshire. xliv, 60p. 20*s.* Cardiganshire and Pembrokeshire. xliv, 60 p. 20*s.* Merionethshire, Montgomeryshire and Radnorshire. xlvi, 77p. 21*s.* London, H.M.S.O., 1955. 13″.

Medical Research Council. The effect of sugar supplements on dental caries in children; J. D. King, May Mellanby, H. H. Stones and H. N. Green. London, H.M.S.O., 1955. viii, 55p. 9½″. 4*s.* (M.R.C. Spec. Rep. Ser. 288.)

The preservation of proteins by drying: with special reference to the production of dried human serum and plasma for transfusion; by R. I. N. Greaves. London, H.M.S.O., 1946. vi, 54p. 20 plates. 9½″. 4*s.* (M.R.C., Spec. Rep. Ser. 258.)

Ministry of Agriculture and Fisheries. Estimation of growth and mortality in commercial fish populations; by J. A. Gulland ... London, H.M.S.O., 1955. 46p. 10½″. 6*s.* (Fish. Invest. Ser. II, **18,** 9.)

Royal Commission on the Taxation of Profits and Income. Final Report. London, H.M.S.O., 1955. xii, 487p. 9½″. 12*s.* 6*d.* (Cmd. 9474.)

Treasury. Second report of the local government manpower committee ... London, H.M.S.O., 1954. ii, 54p. 9½″. 1*s.* 9*d.* (Cmd. 8421.)

Canada. *Dominion Bureau of Statistics.* Ninth census of Canada, 1951. Volume XI: Administrative report. Ottawa, 1955. 289p. fol. tab. 11″. $3.

Egypt. *Statistical and Census Department.* Population census of Egypt, 1947. General tables. Cairo, 1954. v, [2], 493p. 13½″. PT 210.

Germany. *Statistisches Bundesamt.* Die Bewohner in Wohnungen und in Unterkünften ausserhalb von Wohnungen in der Bundesrepublik Deutschland nach der Zählung vom 13.9.1950. Stuttgart-Köln, 1955. 165p. 3 loose maps. 11¾″. (Statistik der Bundesrepublik Deutschland Band 41.)

Der Bestand an Wohnungen und Wohnräumen in der Bundesrepublik Deutschland nach der Zählung vom 13.9.1950. Stuttgart-Köln, 1955. 102p. loose map. 11¾″. (S.B.D. 40.)

Mietpreise und Mietaufkommen (ohne Untermieten) in der Bundesrepublik Deutschland nach der Zählung vom 13.9.1950. Stuttgart-Köln, 1955. 98p. loose map. 11¾″. (S.B.D. 42.)

Die natürliche Bevölkerungsbewegung im Jahre 1953. Stuttgart-Köln, [1955]. 66p. 11¾″. DM 3.50. (S.B.D. 122.)

India. *Bureau of Industrial Statistics.* Survey of retail markets in certain selected areas of West Bengal. (Conducted at the instance of the Government of India, Ministry of Commerce and Industry) by T. Ghose ... Calcutta, 1955. iv, 118p. 11¾″.

Luxembourg. *Ministère des Affaires Économiques.* Les subventions dans les dépenses publiques au Grand-Duché de Luxembourg. Luxembourg, Service d'Études et de Documentation Économiques, 1955. 87p. 9½″. (Cahiers Économiques du Service d'Etudes. 11.)

Malta. *Central Office of Statistics.* Shipping and aviation statistics of the Maltese Islands. Malta, Central Office of Statistics in collaboration with the Customs and Port Department, 1955. [vi] vi, 69p. 12″.

Organisation for European Economic Co-operation. Measurement of productivity; methods used by the Bureau of Labour Statistics in the U.S.A. Paris, O.E.E.C., 1952. 104p. 9¼″. (Technical Assistance Mission Nos. 7–10–11.)

The measurement of agricultural production and food consumption. Paris, O.E.E.C., 1955. London, H.M.S.O. 29, [12] p. 9½″. 3*s.*

Switzerland. *Eidgenössisches Statistisches Amt.* Nutztierbestand der Schweiz ... 1951–1954 ... Silos für Viehfutter 1951 ... Bern, 1955. 123, 197p. 11½″. (Statistische Quellenwerke der Schweiz, Heft 271.)

Eidgenössische Volkszählung, 1. Dezember, 1950. Band 6. Canton de Fribourg. 150p. 12¾″. Band 4. Kantone Basel-Stadt und Basel-Landschaft. 240 p. 11″. Bern, 1955. 2 vols. (Statistische Quellenwerke der Schweiz, Heft 269, 268.)

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United Nations. *Department of Public Information.* Ten years of United Nations publications, 1945 to 1955: a complete catalogue. New York, 1955. London, H.M.S.O. viii, 271p. 9″. 2*s.*

Educational, Scientific and Cultural Organization. International bibliography of economics. (Works published in 1952) ... Vol. 1. Prepared by the Fondation Nationale des Sciences Politiques (Paris) with the assistance of the International Economic Association and the International Committee for Social Science Documentation ... Paris, U.N.E.S.C.O., 1955. 429p. 9½″. 42*s.*

Statistical Office. Handbook of statistical organization. New York, Statistical Office of the United Nations, 1954. Iv, 138p. 11″. (Studies in Methods ... Ser. F. 6.)

United States of America. *National Bureau of Standards.* Computer development (SEAC and DYSEAC) at the National Bureau of Standards, Washington, D.C. Washington, Supt. of Documents, 1955. iv, 146p. 10″. $2. (National Bureau of Standards. Circular 551.)

Department of Health, Education and Welfare. The National Institutes of Health annual lectures, 1953: five lectures delivered at the National Institutes of Health during the year 1953. Washington, Supt. Documents, 1954. iii, 102p. 9″. (Public Health Service Publ. 388.)

II.—AUTHORS AND MISCELLANEOUS

Barnett, H. A. R. The components of mortality. [Institute of Actuaries, submitted January, 1955] 27p. 8¾″.

Belz, Maurice H. & Hooke, Robert. Approximate distribution of the range in the neighborhood of low percentage points. *J. Amer. Statist. Ass.* (1954), **49**, 620–636. 9¾″.

Berkson, Joseph. Maximum likelihood and minimum χ^2 estimates of the logistic function. *J. Amer. Statist. Ass.* (1955), **50**, 130–162. 9¼″.

Binet, F. E. The fitting of the positive binomial distribution when both parameters are estimated from the sample. *Ann. Eugen. Lond.* (1953), **18**, 117–119. 10¾″.

Notes on a remark by Lord Russell. *Brit. J. Phil. Sci.* (1954), **5**, 67–70. 10¾″.

Butler, D. E. The British general election of 1951. London, Macmillan, 1952. viii, 289p. 8½″. 21*s.*

Cambridge University. Department of Applied Economics. The consumption of food in relation to household composition and income; J. A. C. Brown. *Econometrica* (1954), **22**, 444–460. 9¾″. (Repr. Ser. 89.)

An estimation problem in quantitative assay; J. Aitchison and J. A. C. Brown. *Biometrika* (1954), **41**, 338–343. 10¾″. (Repr. Ser. 87.)

La forme des courbes d'Engel; H. S. Houthakker. *Cah. Séminaire d'Économétrie* (1953), 59–66. 10¼″. (Repr. Ser. 88.)

Cartter, Allan Murray. The redistribution of income in postwar Britain: a study in the effects of the central government fiscal program in 1948–49. New Haven, Yale University Press, 1955. London, Cumberlege. xi, 242p. 9¼″. 40*s.* (Yale Studies in Economics 3.)

Churchman, C. West. Theory of experimental inference. New York, Macmillan, [1954]. xii, 292p. 8½″. 35*s.*

Clifford, H. T. & Binet, F. E. A quantitative study of presumed hybrid swarm between *Eucalyptus Elaeophora* and *E. Goniocalyx*. *Aust. J. Bot.* (1954), **2**, 325–336. 9½″.

Colerus, Egmont. From simple numbers to the calculus: mathematics for everyman; by Egmont Colerus. Translated by B. C. and H. F. Brookes. London, Heinemann, 1954. xii, 255p. 7″. 12*s.* 6*d.*

Cramér, Harald. The elements of probability theory and some of its applications. New York, Wiley, 1955. London, Chapman & Hall. 281p. tabs, diagrs. 10″. 56*s.* (Wiley Publications in Statistics.)

Diesslin, Howard G. Agricultural equipment financing. New York, Nat. Bur. of Economic Research, 1955. xvi, 95p. 9″. $1.25. (N.B.E.R., Occ. Pap. 50.)

Dudding, Bernard P. & Keen, Joan. Statistical methods and specifications. *Bull. Int. Statist. Inst.* (1949), **32**, 2, 39–47. 10″.

Falk Project for Economic Research in Israel. 1st Annual report, 1954. Jerusalem, Jerusalem Post Press, 1955. 51, 41p. tabs. 9½″.

Freedman, Maurice, *editor.* A minority in Britain: social studies of the Anglo-Jewish Community; [by] James Parkes, Hannah Neustatter, Howard M. Brotz, Maurice Freedman. London, Valentine, Mitchell, 1955. xvi, 279p. 8½″. 21*s.*

Fruchter, Benjamin. Introduction to factor analysis. New York, Van Nostrand, 1954. London, Macmillan. xii, 280p. tabs, diagrs. 9″. 37*s.* 6*d.* (Van Nostrand Series in Psychology.)

Gilet, P. M. & Watson, G. S. Calculation of accuracy of results of graphical square intercomparisons. *Aust. J. Physics* (1953), **6**, 155–170. 9¼″.

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Goldsmith, Raymond W. A study of saving in the United States . . . Vol. I: Introduction; tables of annual estimates of saving 1897 to 1949. Vol. II: Nature and derivation of annual estimates of saving 1897 to 1949. Princeton University Press, 1955. London, Geoffrey Cumberlege. 2 vols. 9½″. 240*s*.

Good, I. J. The joint distribution for the sizes of the generations in a cascade process. *Proc. Camb. Phil. Soc.* (1955), **51**, 240–242. 10″.

Guilford, J. P. Psychometric methods. 2nd ed. N.Y. & London, McGraw-Hill, 1954. x, 597p. 9″. 61*s*. (McGraw-Hill Series in Psychology.)

Hall, H. Duncan. North American supply. London, H.M.S.O., Longmans, Green, 1955. xvi, 559p. 9½″. 35*s*. (History of the Second World War. U.K. Series. War Production Series.)

Herdan, Gustav. Statistics of therapeutic trials. London [etc.], Elsevier, 1955. xvi, 367p. 9″. 50*s*.

Hill, Austin Bradford. Principles of medical statistics. 6th ed. London, *The Lancet*, 1955. x, 314p. tabs, diagrs. 9½″. 10*s*. 6*d*.

Hogben, Lancelot. Chance and choice by cardpack and chessboard: an introduction to probability in practice by visual aids. Vol. II. London, Max Parrish, 1955. vi, 428–917p. diagrs. 10″. 70*s*.

Ilersic, A. R. Government finance and fiscal policy in post-war Britain. London, Staples Press, 1955. 278p. 8½″. 25*s*.

James, G. S. The comparison of several groups of observations when the ratios of the population variances are unknown. *Biometrika* (1951), **38**, 324–329. 10¾″

Notes on a theorem of Cochran. *Proc. Camb. Phil. Soc.* (1952), **48**, 443–446. 10″.

Tests of linear hypotheses in univariate and multivariate analysis when the ratios of the population variances are unknown. *Biometrika* (1954), **41**, 19–43. 10¾″.

Jones, I. Glyn. Essentials of economics. 2nd ed. London, Gee & Co., 1955. 335p. 8½″. 21*s*.

Keen, Joan *and others*. Correlation for the non-mathematician: Part I by Joan Keen & D. J. Page. Part II by Joan Keen & A. N. James. *Incorporated Statistician* (1953), **4**, 35–65, 128–135. 15p. 8½″.

Keen, Joan & Page, Denys J. Estimating variability from the differences between successive readings. *Appl. Statist.* (1953), **2**, 13–23. 9¾″.

A study of lives of pots used in making glass. *Appl. Statist.* (1952), **1**, 163–168. plate. 9¾″.

Keen, Joan & Watts, Sheila. Forecasting sales. *Accountancy* (1955), February. 4p. 11″. [Read before the London Group, Industrial Applications Section of the Royal Statistical Society, March 5, 1954.]

Kendall. Maurice G. Rank correlation methods. 2nd ed. Revised and enlarged. London, Charles Griffin, 1955. viii, 195p. 9″. 36*s*.

Kendrick, M. Slade. A century and a half of federal expenditure; M. Slade Kendrick, assisted by Mark Wehle. New York, Nat. Bur. of Economic Research, 1955. x, 102p. 9″. $1.25. (N.B.E.R., Occ. Pap. 48. Revised.)

Lancaster, H. O. Ageing in the Australian population. *Med. J. Aust.* (1954), 548. 8p. 10¾″.

Deafness due to rubella. *Med. J. Aust.* (1954), 323. 1p. 11¾″.

The epidemiology of deafness due to maternal rubella. *Acta genet.* (1954), **5**, 12–24. 9″.

The mortality in Australia from cancers of the respiratory system. *Med. J. Aust.* (1953), 355. 2p. diagr. 11″.

Mayne, Alan J. Some further results in the theory of pedestrians and road traffic. *Biometrika* (1954), **41**, 375–389. 10¾″

Mehta, M. M. Measurement of industrial productivity; by M. M. Mehta . . . Calcutta . . . World Press, 1955. [iv], iii, 98p. 8½″. 10*s*. 6*d*.

Mendès-France, Pierre, & Ardant, Gabriel. Economics and action. London, Heinemann, 1955. Paris, U.N.E.S.C.O. 222p. 8½″. 15*s*.

Moore, N. W. Population density in adult dragonflies (*Odonata-Anisoptera*). *J. Anim. Ecol.* (1953), **22**, 344–359. 10″.

National Bureau of Economic Research. Business concentration and price policy: a conference of the Universities-National Bureau Committee for Economic Research. Princeton, University Press, 1955. London, O.U.P. x, 511p. 9″. $9. (Special Conference Series 6.)

Government in economic life; Solomon Fabricant, Director of Research. Thirty-fifth annual report: a record of 1954 and plans for 1955. New York, N.B.E.R., 1955. vi, 78p. 10¾″. (N.B.E.R. Annual Reports 38.)

Nourse, Edwin G. Economics in the public service: administrative aspects of the Employment Act. New York, Harcourt, Brace. London, Allen & Unwin, 1953. xiv, 511p. 8½″. 45*s*.

Ogawara, M. Efficiency of a stochastic prediction. *Pap. Met. Geophys., Tokyo* (1955), **5**, 203–211. 10″.

A general stochastic prediction formula. *Pap. Met. Geophys., Tokyo* (1955), **5**, 193–202. 10″.

Ogawara, M. & Tomatsu, K. A prediction for the next maximum of sunspot numbers. *Pap. Met. Geophys., Tokyo* (1955), **5**, 212–216. 10″.

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Prais, S. J. & Houthakker, H. S. The analysis of family budgets with an application to two British surveys conducted in 1937–9 and their detailed results. Cambridge University Press, 1955. xx, 372p. 9½″. 30*s*. (University of Cambridge, Dept. of Applied Economics. Monographs 4.)

Reece, J. A. Statistics for the cost accountant. [London] Institute of Cost and Works Accountants, 1954. 40p. 9½″. 5*s*. (Occ. Pap. No. 1.)

Riemer, Ruth & Whelpton, P. K. Social and psychological factors affecting fertility; XXVII. Attitudes toward restriction of personal freedom in relation to fertility planning and fertility. *Milbank Mem. Fd. Quart. Bull.* (1955), **33**, 63–111. 9″.

Rissik, H. Quality control in production: a machine-shop manual on the statistical method of controlling product quality during manufacture. London, Pitman, 1947. xviii, 181p. 8½″. 21*s*.

Rostow, W. W. British economy of the nineteenth century: essays by W. W. Rostow. Oxford, Clarendon Press, 1948. [viii], 240p. 8½″. 18*s*.

Schumpeter, Joseph A. History of economic analysis; edited from manuscript by Elizabeth Boody Schumpeter. New York, Oxford University Press, 1954. London, Allen & Unwin. xxv, 1260p. 9″. 124*s*.

Shackle, G. L. S. Uncertainty in economics and other reflections. Cambridge University Press, 1955. xv, 267p. 8½″. 25*s*.

Shephard, Ronald W. Cost and production functions. Princeton, Princeton University Press, 1953. viii, 104p. 9″.

Stevenson, A. C. Muscular dystrophy in Northern Ireland: II. An account of nine additional families. *Ann. Hum. Genet.* (1955), **19**, 159–164. 10½″.

Stevenson, A. C. *and others.* Muscular dystrophy in Northern Ireland : III. Linkage data with particular reference to autosomal limb girdle muscular dystrophy; by A. C. Stevenson and E. A. Cheeseman . . . and Mary Clare Huth . . . *Ann. Hum. Genet.* (1955), **19**, 165–173. 11″.

Stoetzel, Jean. Without the chrysanthemum and the sword: a study of the attitudes of youth in post-war Japan. London, Heinemann, 1955. Paris, U.N.E.S.C.O. 334p., 11 plates. 9½″. 16*s*.

Sutton, C. E. The elements of management accounting. London, Incorporated Accountants Research Committee, 1954. 15p. 9¾″. 4*s*.

Swerling, Boris C. Capital shortage and labor surplus in the United States. *Rev. Econ. Statist.* (1954), **36**, 286–289 . 10¾″.

The International Sugar Agreement of 1953. *Amer. Econ. Rev.* (1954), **44**, 837–853. 9¼″.

Theil, H. Linear aggregation of economic relations. Amsterdam, North-Holland Publishing Co., 1954. xi, 205p. 8½″. 36*s*. (Contributions to Economic Analysis 7.)

Tintner, Gerhard. Mathematics and statistics for economists. New York, Rinehart & Co., 1954. London, Constable. xiv, 363p. 9″. 30*s*.

Westoff, Charles F. & Borgatta, Edgar F. Social and psychological factors affecting fertility: XXVI. The prediction of planned fertility. *Milbank Mem. Fd. Quart. Bull.*, (1955), **33**, 50–62. 13p. 9″.

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REGISTRATION OF THE UNITED KINGDOM AND EIRE

No. I.—ENGLAND AND WALES

BIRTHS, DEATHS *and* MARRIAGES *registered in the Calendar years* 1950–1954 *and in the Quarters of those years. Numbers, Annual and Quarterly Rates* per* 1,000 *persons living. (Deaths under* 1 *year of age; rate per* 1,000 *related Live Births. Stillbirths per* 1,000 *births).*

Years	1950		1951		1952		1953		1954†	
Estimated Mid-year Home Popn. in thousands‡	43,830		43,800§		43,940		44,090		44,274	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Live births	691,760	15·8	679,689	15·5	673,286	15·3	681,964	15·5	673,212	15·2
Stillbirths	16,055	22·7	16,019	23·0	15,647	22·7	15,683	22·5	16,130	24·0
Deaths[1]	510,301	11·6	549,380	12·5	497,484	11·3	503,529	11·4	501,878	11·3
Marriages	358,490	8·2	360,624	8·2	349,308	8·0	344,998	7·8	340,619	7·7
Infant Mortality	20,817	29·6	20,223	29·7	18,555	27·6	18,324	26·8	17,098	25·5
Effective Reproduction Rate[2]	1·017		1·001		1·009		1·035		—	
Quarters	Live Births in the Quarters of each Calendar Year									
Jan.–March	180,130	16·7	176,047	16·3	173,338	15·9	171,649	15·8	173,784	15·9
Apr.–June	181,343	16·6	181,614	16·6	174,159	15·9	179,477	16·3	175,466	15·9
July–Sept.	170,087	15·4	168,033	15·2	168,030	15·2	172,943	15·6	167,070	15·0
Oct.–Dec.	160,200	14·5	153,995	13·9	157,759	14·3	157,895	14·2	156,892	14·1
	Stillbirths									
Jan.–March	4,238	23·0	4,259	23·6	4,174	23·5	3,975	22·6	4,220	23·7
Apr.–June	4,172	22·5	4,196	22·6	4,004	22·5	4,220	23·0	4,153	23·1
July–Sept.	3,919	22·5	3,752	21·8	3,714	21·6	3,711	21·0	3,918	22·9
Oct.–Dec.	3,726	22·7	3,812	24·2	3,755	23·2	3,777	23·4	3,839	23·8
	Deaths[1] (excluding Stillbirths)									
Jan.–March	151,284	14·0	205,878	19·1	146,948	13·5	171,350	15·8	153,116	14·0
April–June	120,791	11·1	121,683	11·1	115,369	10·6	114,644	10·4	117,233	10·6
July–Sept.	102,867	9·3	100,057	9·1	98,613	8·9	98,545	8·9	104,112	9·3
Oct.–Dec.	135,359	12·3	121,762	11·0	136,554	12·4	118,990	10·7	127,417	11·4
	Marriages									
Jan.–March	86,900	8·0	109,567	10·2	106,629	9·8	93,610	8·6	95,669	8·8
April–June	80,726	7·4	66,382	6·1	69,489	6·4	77,123	7·0	74,231	6·7
July–Sept.	114,828	10·4	111,312	10·1	103,411	9·4	105,614	9·5	104,315	9·3
Oct.–Dec.	76,036	6·9	73,363	6·7	69,779	6·3	68,651	6·2	66,404	6·0
	Infant Mortality									
Jan.–March	6,575	36·8	6,572	38·4	5,629	33·6	5,709	34·0	5,239	31·0
April–June	5,034	27·8	5,066	28·6	4,332	25·1	4,448	25·2	4,262	24·7
July–Sept.	4,176	23·9	4,003	23·4	3,863	22·8	3,862	22·2	3,530	21·0
Oct.–Dec.	5,032	30·0	4,582	28·5	4,731	29·0	4,305	26·2	4,067	25·3

* All rates are based on the estimated home population as at the middle of the corresponding year.
‡ Home population comprises the resident civilian population plus any British, Commonwealth or Allied Armed Forces stationed in the country.
† Provisional figures.
§ Examination in the light of the Census data indicated that the estimates of preceding years had become inflated and that but for this, a population increase of some 46,000 would have been recorded for the year 1950/51 instead of the decline of 30,000 shown above.
[1] Including deaths of non-civilians registered in England and Wales.
[2] These reproduction rates correspond to the births which occurred in each year and make allowance for a continuing improvement in survivorship conditions. (Revised values.)

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No. II.—SCOTLAND

BIRTHS, DEATHS *and* MARRIAGES *registered in the Calendar years* 1950–1954 *and in the Quarters of those years. Numbers, Annual and Quarterly Rates* per* 1,000 *persons living. (Deaths under* 1 *year of age, rate per* 1,000 *Live Births; Stillbirths per* 1,000 *Births).*

Years	1950		1951		1952		1953		1954†	
Estimated Mid-year Popn. in thousands‡	5,126§		5,114		5,114		5,118		5,123	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Live Births	92,530	18·1	90,639	17·7	90,442	17·7	90,913	17·8	92,315	18·0
Stillbirths	2,557	27	2,479	27	2,430	26	2,308	25	2,399	25
Deaths	63,996	12·4	65,778	12·9	61,510	12·0	58,878	11·5	61,379	12·0
Marriages	40,459	7·8	41,383	8·1	41,163	8·0	40,927	8·0	41,977	8·2
Infant Mortality	3,569	39	3,391	37	3,181	35	2,800	31	2,861	31
Quarters	**Live Births in the Quarters of each Calendar Year**									
Jan.–March	23,542	18·5	23,625	18·8	22,892	18·0	22,860	18·1	23,456	18·6
April–June	24,646	19·1	24,310	19·1	23,531	18·5	23,791	18·6	24,097	18·9
July–Sept.	22,498	17·3	21,932	17·0	22,161	17·3	22,166	17·2	22,823	17·7
Oct.–Dec.	21,844	16·8	20,772	16·1	21,838	17·0	22,096	17·1	21,939	17·0
	Stillbirths									
Jan.–March	673	28	657	27	677	29	602	26	612	25
April–June	659	26	658	26	598	25	586	24	628	25
July–Sept.	627	27	575	26	541	24	561	25	599	26
Oct.–Dec.	598	27	589	28	614	27	559	25	560	25
	Deaths (excluding Stillbirths)									
Jan.–March	18,647	14·7	22,428	17·8	18,394	14·5	17,264	13·7	18,003	14·3
April–June	14,986	11·6	15,442	12·1	14,270	11·2	14,345	11·2	14,638	11·5
July–Sept.	13,341	10·2	13,104	10·2	12,813	10·0	12,722	9·9	13,327	10·3
Oct.–Dec.	17,022	13·1	14,804	11·5	16,033	12·5	14,547	11·3	15,411	11·9
	Marriages									
Jan.–March	11,111	8·7	11,566	9·2	12,423	9·8	12,092	9·6	12,372	9·8
April–June	8,680	6·7	8,963	7·0	8,158	6·4	8,218	6·4	8,554	6·7
July–Sept	11,847	9·1	12,054	9·4	11,896	9·3	12,076	9·4	12,490	9·7
Oct.–Dec.	8,821	6·8	8,800	6·8	8,686	6·8	8,541	6·6	8,561	6·6
	Infant Mortality									
Jan.–March	1,080	46	1,088	46	872	38	776	34	892	38
April–June	841	34	850	35	801	34	696	29	728	30
July–Sept.	737	33	698	32	663	30	614	28	555	24
Oct.–Dec.	911	42	755	36	845	39	714	32	686	31

* Death Rates are based on all deaths registered in Scotland, related to the home population.
† Provisional figures.
‡ The population is taken to be the civil population (including members of the Mercantile Marine for the time being in Scotland) and members of the armed forces stationed in Scotland.
§ Adjusted in consideration of the 1951 Census returns.

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No. III.—NORTHERN IRELAND

BIRTHS, DEATHS *and* MARRIAGES *registered in the Calendar years* 1950–1954 *and in the Quarters of those years. Numbers, Annual and Quarterly Rates* per* 1,000 *persons living. (Deaths under* 1 *year of age, rate per* 1,000 *Live Births).*

Years	1950		1951		1952		1953		1954†	
Estimated Mid-year Popn. in thousands*	1,369		1,373		1,375		1,384		1,387	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Live births	28,794	*21·0*	28,477	*20·7*	28,760	*20·9*	28,984	*20·9*	28,803	*20·8*
Stillbirths[1]					Not registered					
Deaths‡	15,839	*11·6*	17,628	*12·8*	14,812	*10·8*	14,813	*10·7*	15,124	*10·9*
Marriages	9,084	*6·6*	9,414	*6·9*	9,300	*6·8*	9,416	*6·8*	9,060	*6·5*
Infant Mortality	1,166	*40*	1,173	*41*	1,117	*39*	1,090	*38*	951	*33*
Quarters	Live Births in the Quarters of each Calendar Year									
Jan.–March	7,275	*21·3*	7,254	*21·2*	7,095	*20·8*	7,212	*21·3*	7,253	*21·3*
April–June	7,725	*22·5*	7,769	*22·6*	7,589	*22·2*	7,902	*22·9*	7,704	*22·3*
July–Sept.	7,090	*20·7*	7,089	*20·5*	7,215	*20·9*	7,254	*20·8*	7,089	*20·3*
Oct.–Dec.	6,704	*19·5*	6,365	*18·4*	6,861	*19·9*	6,616	*19·0*	6,757	*19·3*
	Deaths‡ (excluding Stillbirths)									
Jan.–March	4,551	*13·3*	6,971	*20·4*	4,450	*13·0*	4,541	*13·4*	4,311	*12·6*
April–June	3,925	*11·4*	3,951	*11·5*	3,671	*10·7*	3,734	*10·8*	3,985	*11·5*
July–Sept.	3,222	*9·4*	3,211	*9·3*	3,093	*9·0*	3,075	*8·8*	3,197	*9·1*
Oct.–Dec.	4,141	*12·1*	3,495	*10·1*	3,598	*10·4*	3,463	*9·9*	3,631	*10·4*
	Marriages									
Jan.–March	2,055	*6·0*	2,210	*6·5*	2,272	*6·7*	2,022	*6·0*	2,072	*6·1*
April–June	2,023	*6·1*	1,958	*5·7*	2,099	*6·1*	2,288	*6·6*	2,111	*6·1*
July–Sept.	3,066	*9·0*	3,174	*9·0*	2,988	*8·7*	3,235	*9·2*	3,123	*8·9*
Oct.–Dec.	1,882	*5·5*	2,072	*5·9*	1,941	*5·6*	1,871	*5·4*	1,754	*5·0*
	Infant Mortality									
Jan.–March	323	*44*	371	*51*	317	*45*	332	*46*	285	*39*
April–June	284	*37*	292	*38*	288	*38*	294	*37*	245	*32*
July–Sept.	253	*36*	255	*36*	232	*32*	225	*31*	202	*28*
Oct.–Dec.	305	*45*	255	*40*	280	*41*	239	*36*	219	*32*

* For 1950 rates are based on Civilian Population only ; for 1951–54 they are based on " Home Population " (Civilians and Members of H.M. Forces stationed in Northern Ireland).
† Provisional figures.
‡ For 1950 civilian deaths only ; for 1951–54, total deaths registered.
[1] Stillbirths are not registered in Northern Ireland. The birth of one living child and one stillborn, or one living child and two stillborn, is counted as one birth.

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No. IV.—EIRE

BIRTHS, DEATHS *and* MARRIAGES *registered in the Calendar years* 1950–1954 *and in the Quarters of those years. Numbers, Annual and Quarterly Rates* per* 1,000 *persons living. (Deaths under* 1 *year of age, rate per* 1,000 *Live Births).*

Years	1950		1951		1952†		1953†		1954†	
Estimated Mid-year Popn. in thousands	2,969		2,959		2,948		2,942		2,933	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Livebirths	63,565	*21·4*	62,878	*21·2*	64,226	*21·8*	62,202	*21·1*	61,897	*21·1*
Stillbirths‡					Not registered					
Deaths	37,741	*12·7*	42,382	*14·3*	35,155	*11·9*	34,585	*11·8*	35,570	*12·1*
Marriages	16,018	*5·4*	16,017	*5·4*	15,769	*5·3*	15,603	*5·3*	15,757	*5·4*
Infant Mortality	2,922	*46*	2,876	*46*	2,646	*41*	2,448	*39*	2,345	*38*
Quarters	Live Births in the Quarters of each Calendar Year									
Jan.–March	15,843	*21·3*	15,727	*21·2*	16,090	*21·8*	15,692	*21·3*	15,278	*20·8*
April–June	17,172	*23·1*	16,966	*22·9*	17,524	*23·8*	16,761	*22·8*	16,142	*22·0*
July–Sept.	15,960	*21·5*	16,299	*22·0*	15,845	*21·5*	15,702	*21·3*	15,837	*21·6*
Oct.–Dec.	14,590	*19·7*	13,886	*18·8*	14,767	*20·0*	14,047	*19·1*	14,640	*20·0*
	Deaths (excluding Stillbirths)									
Jan.–March	11,172	*15·1*	16,659	*22·5*	10,658	*14·4*	10,555	*14·3*	10,468	*14·2*
April–June	9,687	*13·1*	10,205	*13·8*	8,731	*11·8*	8,926	*12·1*	8,861	*12·1*
July–Sept.	7,690	*10·4*	7,584	*10·2*	7,267	*9·9*	7,129	*9·7*	7,708	*10·5*
Oct.–Dec.	9,192	*12·4*	7,934	*10·7*	8,499	*11·5*	7,975	*10·8*	8,533	*11·6*
	Marriages									
Jan.–March	3,429	*4·6*	3,389	*4·6*	3,441	*4·7*	2,935	*4·0*	3,237	*4·4*
April–June	3,813	*5·1*	3,857	*5·2*	3,692	*5·0*	3,771	*5·1*	3,687	*5·0*
July–Sept.	5,410	*7·3*	5,437	*7·3*	5,207	*7·1*	5,435	*7·4*	5,530	*7·5*
Oct.–Dec.	3,366	*4·5*	3,334	*4·5*	3,429	*4·7*	3,462	*4·7*	3,303	*4·5*
	Infant Mortality									
Jan.–March	962	*61*	928	*59*	877	*55*	698	*44*	743	*49*
April–June	778	*45*	783	*46*	611	*35*	682	*41*	589	*36*
July–Sept.	584	*37*	596	*37*	567	*36*	514	*33*	469	*30*
Oct.–Dec.	598	*41*	569	*41*	591	*40*	554	*39*	544	*37*

* Rates are based on the total estimated population as at the middle of the corresponding year.
† Provisional figures.
‡ Stillbirths are not registered in Eire. The births of one living and one stillborn, or of one living child and two stillborn are counted as one birth.

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Vol. 118.] [Part IV

Journal of the Royal Statistical Society

SERIES A (GENERAL)

PART IV, 1955.

A Unified Derivation of Some Well-known Frequency Distributions of Interest in Biometry and Statistics

By J. O. Irwin

Statistical Research Unit, Medical Research Council

[Read before the Royal Statistical Society May 25th 1955, Professor A. Bradford Hill, F.R.S., Honorary Vice-President, in the Chair]

I propose in this paper to look at some very well-known frequency-distributions from a unified point of view. This point of view will, I believe, be novel to many people, though the approach goes back to at least two of the classical writers on probability; and it has the merit of leading to extremely simple derivations.

The subject matter formed part of some lectures given at University College in 1953, and it was represented to me that as some of my audience would wish to go on with original research from where I left off it might help them if I published my own contributions. I have already met this request by publishing in Series B a short paper on the relation between transition probabilities and factorial moments in cases where a stochastic model is appropriate. That paper contained the only unquestionably new material; here whatever novelty there may be is confined to the method of exposition.

When I started lecturing on probability at University College many years ago, I depended a great deal on that classical little book Whitworth's *Choice and Chance* (1878, Prop. XV). In it there is a general theorem which seemed to me to have been largely ignored of recent years, but by the use of which a number of interesting statistical distributions may be derived. It is as follows:

"If there be N sets of letters and if out of r assigned letters $\alpha_1, \alpha_2 \ \ldots \ \alpha_r$ each letter (such as α_1) occurs in N_1 sets, each combination of 2 letters (such as $\alpha_1\,\alpha_2$) occurs in N_2 sets; each combination of 3 letters (such as $\alpha_1\,\alpha_2\,\alpha_3$) in N_3 sets and so on, and finally all the r letters occur in N_r sets, the number of sets free from all the letters will be

$$N - \frac{r}{1!}N_1 + \frac{r(r-1)}{2!}N_2 - \frac{r(r-1)(r-2)}{3!}N_3 + \ \ldots \ + (-1)^r N_r.$$

The proposition is easily proved by induction. Whitworth remarks that the reasoning being perfectly general the proposition may be enunciated in general terms as follows:

If there be N events or operations and if, out of r possible conditions $(\alpha_1, \alpha_2 \ \ldots \ \alpha_r)$ every one condition such as (α_1) is fulfilled in N_1 of the events, every combination of 2 simultaneous conditions such as $(\alpha_1\,\alpha_2)$ be fulfilled in N_2 of the events and so on, and finally all r conditions be simultaneously fulfilled in N_r of the events, then the number of events free from all the conditions is

$$N - \frac{r}{1!}N_1 + \frac{r(r-1)}{2!}N_2 + \ \ldots \ (-1)^r N_r.$$

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I propose to use Whitworth's Theorem to derive—

(1) The Matching Distribution.
(2) The distribution of the number of occupied classes when n objects are assigned randomly to k different classes.
(3) The distribution of the greatest interval when a line of fixed length is divided into n intervals by $(n-1)$ randomly placed points.

The last distribution is that which occurs in Fisher's modification of Schuster's Criterion.

1. *The Matching Distribution*

Suppose that we have photographs of 10 people and also specimens of their handwriting and we try and allocate the specimens to the correct people. Suppose further that we get 5 right. Is this result likely to arise by chance if we are just guessing? In other words, if we have two sets of n objects each numbered 1, 2, 3, . . . n and each is arranged in a random order, so as to form n pairs, what is the chance that on r pairs the two numbers are the same?; or what is the frequency distribution of r the number of correctly matched pairs?

The solution is an easy application of Whitworth's Theorem. For suppose r pairs are correct, these may be selected in $\binom{n}{r}$ ways and the remaining $(n-r)$ must be incorrect. Now k objects can be arranged in $k!$ orders; one particular object is in the right place in $(k-1)!$ of these orders, 2 particular objects are in the right place in $(k-2)!$ orders, in general t particular objects in $(k-t)!$ of these orders. Hence by Whitworth's Theorem all the objects are in the wrong places in

$$k! - k(k-1)! + \frac{k(k-1)}{2!}(k-2)! - \ \ldots \ + (-1)^t\binom{k}{t}(k-2)! \ \ldots \ + (-1)^k$$
$$= k!\left(1 - \frac{1}{1!} + \frac{1}{2!} - \ \ldots \ + \frac{(-1)^k}{k!}\right).$$

This quantity is called sub-factorial k (Whitworth wrote it $\underline{|k}$). It is the nearest integer to $k!/e$. Hence the chance that out of the n pairs above, r are in the correct order is

$$\frac{1}{n!}\binom{n}{r}\underline{|n-r}$$
$$= \frac{1}{r!}\left(1 - \frac{1}{1!} + \frac{1}{2!} - \ \ldots \ + \frac{(-1)^{n-r}}{(n-r)!}\right).$$

This is very close to $e^{-1}/r!$ so the frequency distribution is clearly very close to the Poisson distribution with mean unity. It can in fact be shown that the first n cumulants are the same as those of the Poisson with mean unity. Let us write down the probabilities in a form which is exemplified by the case of $n = 4$ below:

r	
0	$1 - \frac{1}{1!} + \frac{1}{2!} - \frac{1}{3!} + \frac{1}{4!}$
1	$\frac{1}{1!0!} - \frac{1}{1!1!} + \frac{1}{1!2!} - \frac{1}{1!3!}$
2	$\frac{1}{2!0!} - \frac{1}{2!1!} + \frac{1}{2!2!}$
3	$\frac{1}{3!0!} - \frac{1}{3!1!}$
4	$\frac{1}{4!}$

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Then let us multiply p_r by e^{tr} and add (summing in diagonals sloping down from right to left). This gives for the m.g.f.

$$M(t) = 1 - (1 - e^t) + \frac{1}{2!}(1 - e^t)^2 - \frac{1}{3!}(1 - e^t)^3 \quad \ldots \quad \frac{(-1)^r}{r!}(1 - e^t)^r \quad \ldots + \frac{(-1)^n}{n!}(1 - e^t)^n.$$

Now up to t^n this expression will not be altered by continuing the series to infinity; therefore we may, for the purpose of obtaining the first n moments or cumulants, take

$$M(t) = \exp\{-(1 - e^t)\}$$
$$K(t) = \log M(t) = e^t - 1.$$

But this is the cumulant generating function of the Poisson with mean unity. Thus all the first n cumulants are unity for the matching distribution as for this Poisson.

Since there are $n!$ orders of arranging n objects, it is sometimes convenient to give the frequencies relative to a total of $n!$. If this be done we may note (i) that the frequencies of $r = 0$ and $r = 1$ differ by unity for all n, and (ii) the frequency of $r = (n - 1)$ is always zero. We cannot of course have *one* pair non-corresponding without some other pair doing so. The results are very close to the Poisson even for such a low value as $n = 5$; for $n = 10$ there is at most a discrepancy of 1 in the fifth decimal place (see Table 1). Thus, for instance, if we take 2 packs of cards and turn up the cards from each one at a time, the chance of a given number of correspondences is for practical purposes the same whether the packs contain 10 cards or any larger number, e.g. 100,000.

There is of course quite a considerable literature on the matching problem, which has particularly interested psychologists. More than 2 series of orders might be compared, for example if a number of judges each try and assign a set of photographs to a set of subjects. I have thought it worth while to include references to three papers by P. E. Vernon (1936). The last paper gives a bibliography with 82 references.

2. *Distribution of Number of Occupied Classes when* n *Objects are Assigned Randomly to* k *Different Classes*

Let us suppose that there are k different types of cigarette cards being issued, equally frequently, in packets of cigarettes, and that the types are randomly distributed throughout the market. A smoker collects n cards; what is the expected frequency distribution of the number of types represented in his collection? In this problem n will usually be greater than k.

But the same distribution is involved if, for example, in a litter of 5 mice, each mouse is classified genotypically and it is expected that any mouse will be equally likely to belong to any one of 128 different classes (genotypes, $128 = 2^7$). It is required to know the expected distribution of the number of types represented in the 5 mice.

Taking the cigarette card illustration, any particular card can be of k types; there are therefore k^n equally likely possible allocations. If one particular type is absent there are $(k - 1)^n$ possible allocations; if t types are absent there are $(k - t)^n$ possible allocations. Hence the number of allocations in which no types are absent will be, by Whitworth's Theorem

$$k^n - k(k-1)^n + \frac{k(k-1)}{2!}(k-2)^n \quad \ldots \quad + (-1)^n = \Delta^k(0^n)$$

and the corresponding probability is $\Delta^k(0^n)/k^n$

Similarly of the k^n possible allocations, the number in which exactly r particular types occur $(r < k)$ is $\Delta^r(0^n)$ and the r particular types can be selected from the k in $k!/\{r!(k - r)!\}$ ways. Thus the probability that r particular types occur is

$$\frac{k!}{(k-r)!r!}\frac{\Delta^r(0^n)}{k^n}.$$

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We note that

$$\sum_{r=0}^{k} \frac{k!}{(k-r)!r!} \frac{\Delta^r(0^n)}{k^n} = (1+\Delta)^k(0^n)/k^n = E^k(0^n)/k^n = 1$$

which verifies that the total probability is unity. The factorial moments of the distribution are easily obtained. For the f.m.g.f. is—

$$\sum_{r=0}^{k} \frac{k!}{(k-r)!r!} \frac{\Delta^r(0^n)}{k^n} (1+t)^r = \sum_{v=0}^{k} \binom{k}{v} t^v \Delta^v\{(k-v)^r\}/k^n.$$

Thus

$$\mu'_{(v)} = \frac{k!}{(k-v)!} \frac{\Delta^v\{(k-v)^n\}}{k^n}.$$

A table, calculated by Stevens, gives the values of $\Delta^k(0^n)/k!$ for $n = 2(1)\,25$, $k = 2(1)n$ (*Statistical Tables for Agricultural, Biological and Medical Research* (1953), Table XXII).

TABLE 1

Comparison of "Matching" and Poisson Distribution

Number of Correctly Matched Pairs	*Matching,*	n = 10 *Frequency*	*Poisson, Mean Unity Frequency*	*Matching,*	n = 5 *Frequency*
0	1,334,961	·367879	·367879	44	·366667
1	1,334,960	·367879	·367879	45	·375000
2	667,485	·183941	·183940	20	·166667
3	222,480	·061310	·061313	10	·083333
4	55,650	·015336	·015328	0	0
5	11,088	·003056	·003066	1	·008333
6	1,890	·000521	·000511		1·000000
7	240	·000066	·000073		
8	45	·000012	·000009		
9	0	0	1		
10	1	·000003	0		
	3,628,800	1·000000 (3)	·999999	120	1·000000

In the cigarette card problem n might well be very much larger than k; in this case the distribution will be J-shaped and the probability that all types will be represented will approach unity as $n \to \infty$ (see Table 2). Even with $n = 10$, $k = 5$, all types or all except one are present in 94 per cent. of cases.

TABLE 2

Distribution of Number of Occupied Classes when n *Objects are Assigned at Random to* k *Different Classes*

Number Occupied	$n = 10, k = 5$		$n = 5, k = 5$		$n = 5, k = 10$		$n = 5, k = 128$	
r	*Frequency*		*r*	*Frequency*	*r*	*Frequency*	*r*	
1	5	·000001	1	5	·0016	1	10	1	128	0
2	10,220	·001047	2	300	·0960	2	1,350	2	243,840	·000007
3	559,800	·057324	3	1,500	·4800	3	18,000	3	51,206,400	·001490
4	4,092,600	·419082	4	1,200	·3840	4	50,400	4	2,560,320,000	·074515
5	5,103,000	·522547	5	120	·0384	5	30,240	5	31,747,968,000	·923987
						6–10	zero	6–128	zero	
Total	9,765,625	1·000000 (1)		3,125	1·0000		100,000		34,359,738,368	1·000000 (–1)

In the genetical application k can be much larger than n. When $n = 5$ for $k = 5$ the distribution has a mode at $k = 3$; when $n = 5$, $k = 10$ there is a mode at $k = 4$, but classes $r = 6 - 10$

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have of course zero frequency. When $n = 5$, $k = 128$, the distribution is J-shaped up to $r = 5$, but for $r = 6(1)128$ it has zero frequencies; in 99·85 per cent. of cases 4 or 5 classes are occupied, 5 in 92·40 per cent. Thus with increasing k and fixed n the distribution tends to become concentrated round $r = n$. Each object is almost certain to be of a different type.

Stevens (1937) has considered the case where a large number of litters of mice are available, and the individuals have been classified into a number of different genotypes (128 in one of his examples). The litters may be of different sizes and there may be small variations in probability from one genotype to another. It is desired to test the hypothesis that the mice in a litter are distributed randomly and independently among the different classes (genotypes). This for example would be disturbed by the occurrence of twins from the same fertilized egg. He uses a method of scoring:

Let n = size of litter
r = number of occupied classes (genotypes occurring)
z = number of unoccupied classes (genotypes not occurring)
k = total number of classes (genotypes)

Further let t be the number of identities, it being understood that a pair of objects in one class is an identity, and a set of x objects in one class counts as $(x - 1)$ identities. The symbol t is suggested by the word "twins". Then if there are a_x classes with x objects in them

$$n = \Sigma a_x x$$
$$= \Sigma a_x(x - 1)$$
$$n - t = \Sigma a_x = r \text{ say.}$$

We find

$$z = k - r$$
$$t = n - r$$

or

$$t = z + n - k.$$

Thus for a fixed n and k, t and z differ by constants and of course $r + z = k$ a constant.

The litter could have a score assigned to its and either z, r or t could be used; their sampling frequency distributions apart from position (mean value) would be identical. Stevens uses t. He gets a total score by adding the values of t for all litters and, by using the distribution we have been discussing, he works out the expected value of the total score and its sampling variance. In a practical case, where there are a large number of litters, the total score will be very closely normally distributed, thus a significance test can be obtained from

$$\frac{\text{Observed Total Score} - \text{Expected Score}}{\text{S.E. of Score}}$$

Thus he was able to test the evidence for the existence of monozygotic twins.

3. *Distribution of the Greatest Interval when a Line of Fixed Length is Divided into* n *Intervals by* (n − 1) *Randomly Placed Points.*

Consider a line of fixed length u, divided by $(n - 1)$ randomly placed points into n intervals, $x_1, x_2, \ldots x_n$. Let X be the greatest of these intervals. We shall show that $P = P\{X/u \geqslant g\}$ is given by

$$P = n(1 - g)^{n-1} - \frac{n(n-1)}{2!}(1 - 2g)^{n-1} + \ldots (-1)^{r-1}\binom{n}{r}(1 - rg)^{n-1} + \ldots \quad (1)$$

the series continuing as long as the terms $(1 - rg)^{n-1}$, $r = 1, 2, 3, \ldots$, are positive.

We shall first prove that the probability that any r intervals selected out of the n are all greater than or equal to ug is given by

$$P(x_1 \geqslant ug, x_2 \geqslant ug \ldots x_r \geqslant ug) = (1 - rg)^{n-1} \text{ for } g \leqslant \frac{1}{r} \text{ and } 0 \text{ for } g > \frac{1}{r}. \quad (2)$$

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It then follows by Whitworth's Theorem that the probability that all the intervals are less than ug is $1 - P$, where P is given by (1). Hence the probability that the greatest interval is greater than or equal to ug is P.

It is clear that for any one interval x_r

$$P(x_r \geqslant x) = \left(1 - \frac{x}{u}\right)^{n-1}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

for $x_r \geqslant x$ if and only if all the $(n-1)$ points fall within a length $(u - x)$. Thus the probability density for any one interval x_r is

$$(n-1)\left(1 - \frac{x}{u}\right)^{n-2} \frac{dx}{u}$$

The corresponding expression for the simultaneous distribution of $x_1, x_2, \ldots x_r$ is

$$(n-1)(n-2) \ . \ . \ (n-r)\left\{1 - \frac{x_1}{u} - \frac{x_2}{u} - \ \ldots \ - \frac{x_r}{u}\right\}^{n-r-1} \frac{dx_1}{u}\frac{dx_2}{u} \ \ldots \ \frac{dx_r}{u} \ . \ . \quad (4)$$

The best way to prove this is to suppose that we have n random intervals selected from a population of intervals with given mean say c, subject to the restriction that their sum is equal to u. The distribution of intervals is then exponential.

For consider a length x and suppose that the unit length is divided into a large number of equal parts h, of length $1/h$. The length x will contain hx such parts, and the probability that any one of them contains a boundary point between two intervals is $1/ch$. The probability it does not is $(1 - 1/ch)$. Thus the probability that the length x contains no boundary point is

$$\lim_{h \to \infty} (1 - 1/ch)^{xh} = e^{-x/c}$$

and this is the probability of an interval $> x$.

Thus the probability density for $x_1, x_2 \ \ldots \ x_n$ is

$$c^{-n} e^{-u/c} dx_1 dx_2 \ \ldots \ dx_n. \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Write

$$x_n = u - x_1 - x_2 \ \ldots \ - x_{n-1}$$

and (5) becomes

$$c^{-n} e^{-n/c} du\, dx_1 dx_2 \ \ldots \ dx_{n-1}.$$

Integrating for x_{n-1} between 0 and $u - x_1 - x_2 \ \ldots \ - x_{n-2}$ we find for the joint distribution of u and $x_1, x_2 \ \ldots \ x_{n-2}$

$$c^{-n} e^{-u/c} (u - x_1 - x_2 \ \ldots \ - x_{n-2})\, du\, dx_1 dx_2 \ \ldots \ dx_{n-2}. \quad . \quad . \quad (6)$$

By continuing the process we find the joint distribution of $u, x_1, x_2 \ \ldots \ x_r$ is

$$\frac{1}{(n-r-1)!} c^{-n} e^{-u/c} (u - x_1 - x_2 \ \ldots \ - x_r)^{n-r-1} du\, dx_1 dx_2 \ \ldots \ dx_r \ . \quad (7)$$

and finally the distribution of u is

$$\frac{1}{(n-1)!} e^{-u/c} (u/c)^{n-1} \frac{du}{c} \quad . \quad . \quad . \quad . \quad . \quad (8)$$

as is otherwise known.

Thus (7) can be written

$$\frac{1}{(n-1)!} e^{-u} (u/c)^{n-1} \frac{du}{c} \frac{(n-1)!}{(n-r-1)!} \left(1 - \frac{x_1}{u} - \frac{x_2}{u} \ \ldots \ - \frac{x_r}{u}\right)^{n-r-1} \frac{dx_1}{u} \ \ldots \ \frac{dx_r}{u} \ . \quad (9)$$

and thus the distribution of $x_1, x_2 \ \ldots \ x_r$ for fixed u is given by (4). This must now be integrated for values of $x_1, x_2 \ \ldots \ x_r$, all greater than ug. Remembering that the limits for x_r

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are ug to $u - x_1 - x_2 \ \ldots \ - x_{r-1}$ and proceeding with the integration one variable at a time, (the limits for x_{r-t} are ug to $u(1 - tg) - x_1 - x_2 \ \ldots \ - x_{r-t-1}$) we find

$$P(x_1 > ug,\ x_2 > ug \ \ldots \ x_r > ug) = (1 - rg)^{n-1}.$$

Thus (2) is proved and (1) follows.

As corollaries to this result we have:

(i) The probability that just i of the intervals exceed ug is

$$f(i) = \frac{n!}{i!(n-i)!}\left\{(1 - ig)^{n-1} - \binom{n-i}{1}(1 - (i+1)g)^{n-1} + \ \ldots\right.$$

$$\left. \ldots + (-1)^r \binom{n-i}{r}(1 - (i+r)g)^{n-1} + \ \ldots\right\} \quad . \quad (10)$$

the series continuing as long as $(1 - (i + r)g)$ is positive. This follows because the probability of i specified intervals greater than g is $(1 - ig)^{n-1}$ and of $(i + r)$ specified intervals $(1 - (i + r)g)^{n-1}$. Thus the probability that i specified intervals and any one other interval are all greater than g is $(n - i)(1 - (i + 1)g)^{n-1}$, while the probability that i specified intervals and any r others are all greater than g is

$$\binom{n-i}{r}(1 - (i+r)g)^{n-r}.$$

If we remember that the i specified intervals can be chosen in $\binom{n}{i}$ ways and apply Whitworth's Theorem the corollary (i) follows.

(ii) The probability that i or more intervals are greater than ug is

$$\frac{n!}{(i-1)!(n-i)!}\left\{\frac{(1 - ig)^{n-1}}{i} - \binom{n-i}{1}\frac{(1 - (i+1)g)^{n-1}}{i+1} + \binom{n-i}{2}\frac{(1 - i + 2g)^{n-1}}{i+2}\right.$$

$$\left. \ldots \ + (-1)^r \binom{n-i}{r}\frac{(1 - (i+r)g)^{n-1}}{i+r} \ + \ldots\right. \quad . \quad (11)$$

the series continuing as long as $(1 - (i + r)g)$ is positive. This is proved fairly readily by summing (10).

This distribution was shown by Stevens (1939) to be equivalent to one arising in a certain problem of geometrical probability. n arcs of length x are taken in random positions on the circumference of a circle, and it is required to obtain the frequency distribution of the number of gaps, i.e. portions of the circumference left uncovered. The distribution was obtained by Fisher (1929) in connexion with Schuster's criterion in harmonic analysis. Later (1940) he showed the equivalence to Stevens's problem, and gave a table of 5 per cent. and 1 per cent. points of the distribution of g_1 and g_2, where g_1 is the largest and g_2 the second largest fraction of the whole. The probability of g_1, g_2 exceeding any specified values can be obtained from (10) by putting $i = 1$ $i = 2$ respectively. In practice only the first term of (10) is required. Fisher's original treatment was geometrical, and many people found it somewhat difficult to follow. We have now seen how it can be derived from Whitworth's Theorem.

I am indebted to Mr. E. C. Fieller, who read this manuscript at an early stage, for drawing my attention to a paper by Garwood (1940) on an application of the theory of probability to the operation of vehicular controlled traffic signals. Garwood gives a reference to a proof of (1) by Whitworth (1897) in which the device was used of dividing the line into a number N of equal elements and letting N increase indefinitely. Garwood himself gives a proof of (10) based on the following elementary combinatorial problem treated by Baticle. The number of different ways of arranging m indifferent objects into $n + 1$ non-zero lots so that exactly k of the lots shall contain more than p objects, the order of the lots being taken into consideration is

$$X_k = \binom{n+1}{k}\left[\binom{m - kp - 1}{n} - \binom{n-k+1}{1}\binom{m - (k+1)p - 1}{n}\right.$$

$$\left. + \ \ldots \ (-1)^s \binom{n-k+1}{s}\binom{m - (k+s)p - 1}{n}\right] \quad . \quad (12)$$

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where s is the largest integer satisfying $(k + s)(p + 1) \leqslant m$. This can also be proved by a straightforward application of Whitworth's Theorem, just as (10) above. For we can ensure that k particular lots or more contain at least p objects by putting p objects in them straight away and then distributing the remaining $(m - kp)$ objects among the $n + 1$ lots afterwards. The latter operation can be performed in $\binom{m - kp - 1}{n}$ ways and there are $\binom{n + 1}{k}$ ways of choosing the lots. This gives the first term in (12).

The corresponding expression for $(k + l)$ lots is $\binom{n + 1}{k}\binom{m - (k + l)p - 1}{n}$ and the l additional lots can be chosen in $\binom{n - k + 1}{l}$ ways. Whitworth's Theorem immediately gives (12). By writing $k = i$, $p/m = g$ substituting n for $n + 1$ and letting $p \to \infty$, $m \to \infty$ keeping g finite, equation (10) follows.

Cochran (1941) using a similar argument to that used in this section obtained the distribution of the largest of a set of estimated variances, each based on r degrees of freedom, as a fraction of their total. Finney (1941) extended this to give the distribution of the largest of a number of variance ratios, such as occur in an analysis of variance when a number of independent mean squares with the same number of degrees of freedom are all compared with an error mean square.

4. *Application to Schuster's Criterion in Periodogram Analysis*

Suppose we have a series of observations at equal intervals denoted by $u_1, u_2, u_3 \ldots u_m$ and we require to search for hidden periodicities. The usual procedure (in principle) is to take a series of trial periods m, and to write the observations down in rows of m

$$\begin{array}{lll} u_1 & u_2 & u_m \\ u_{m+1} & & u_{2m} \\ \cdots\cdots & \cdots\cdots & \cdots\cdots \\ u_{(p-1)m+1} & & u_{pm} \end{array}$$

the means of the columns being $\bar{u}_1, \bar{u}_2 \ldots \bar{u}_m$.

If the observations really have a periodic component with period equal to m, the effect of this process of averaging will be to magnify the periodic effect in the column sums, largely to eliminate random variations, and also largely to eliminate periodic components with other periods.

Let us suppose in fact that the observations are actually strictly periodic in M, so that

$$u_r = a \sin\left(\frac{2\pi r}{M} + \alpha\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Then it has been shown many times that for a trial period m

$$\bar{u}_r = \frac{a \sin \dfrac{mp\pi}{M}}{p \sin \dfrac{m\pi}{M}} \sin\left(\frac{2\pi r}{M} + \alpha + \alpha_1\right) \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where

$$\alpha_1 = \frac{(p - 1)\, m\pi}{M}$$

The amplitude of (2) is

$$I = \frac{a}{p} \frac{\sin p\pi X}{\sin \pi X} \text{ where } X = \frac{m}{M} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

If I be plotted against X (or m) we obtain a curve with a central peak at $X = 1$ flanked by smaller peaks, the zeros being at $X = 1 \pm \frac{1}{p}, 1 \pm \frac{2}{p}$, etc.

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The periodogram is obtained by plotting $|I|$ against m. If p is large we get a well defined central peak with a very sharp falling away on either side. Hence, in principle all we have to do is to construct the periodogram and pick out the peaks. In practice the situation is never anything like so clear cut. There may be all sorts of disturbing variations which are not strictly periodic, as well as random variations. Thus we are faced with the problem of deciding which peaks in the periodogram are significant. To test whether any particular peak corresponding to a trial period selected at random is significant we might work out the probability that if the observations were really normally and independently distributed we should obtain a peak greater than that actually observed. This is the basis of Schuster's criterion. We take the values of $\bar{u}_r$ and fit them with a curve of the form

$$\bar{U}_r = A \cos \frac{2\pi r}{m} + B \sin \frac{2\pi r}{m}.$$

If A and B are estimated by least squares we find

$$A = \frac{2}{m} \sum_{r=1}^{m} \bar{u}_r \cos \frac{2\pi r}{m} \qquad B = \frac{2}{m} \sum_{r=1}^{m} \bar{u}_r \sin \frac{2\pi r}{m}$$

$$= \sqrt{\frac{2}{m}} \sum_{r=1}^{m} a_r \bar{u}_r \qquad = \sqrt{\frac{2}{m}} \sum_{r=1}^{m} b_r \bar{u}_r.$$

If the u are normally and independently distributed with variance σ^2, then A and B are also normally distributed. It can be shown that

$$\sum_{r=1}^{m} a_r = 0 \quad \sum_{r=1}^{m} b_r = 0 \quad \sum_{r=1}^{m} a_r^2 = 1 \quad \sum_{r=1}^{m} b_r^2 = 1 \quad \sum_{r=1}^{m} a_r b_r = 0.$$

So A and B are independently and normally distributed with variance $\frac{2\sigma^2}{mp} = \frac{2\sigma^2}{N}$ say.

Thus $A^2 + B^2$, which is the square of the amplitude, has an exponential distribution with mean $c = \frac{4\sigma^2}{N}$.

Thus the probability that, for a trial period selected at random, $(A^2 + B^2)$ will exceed x is $e^{-x/c}$. This is Schuster's criterion. In actual fact however we shall usually select the biggest peak and test that; if the n trial periods we have made are all independent the probability that the largest squared amplitude will exceed x is $1 - (1 - e^{-x/c})^n$. This is Sir Gilbert Walker's modification of Schuster's criterion.

In practice c will be unknown and have to be estimated from the data. The maximum likelihood estimate is the mean $\bar{x}$. Hence our problem is to find the distribution of the greatest value of $(x/\bar{x})$, or the greatest value of $x/\Sigma x$ and that reduces to the problem we have discussed. The probability that the greatest of the n values of $x/\Sigma x$ exceeds g is given by (1) of the previous section; the probability that the 2nd greatest exceeds g is given by putting $i = 2$ in equation (11) of the previous section and is therefore

$$n(n-1)\left\{\frac{(1-2g)^{n-1}}{2} - \frac{(n-2)(1-3g)^{n-1}}{3} + \frac{(n-2)(n-3)}{2!}\frac{(1-4g)^{n-1}}{4} \cdots\right\}. \quad (5)$$

We might sometimes, although doubtful of the significance of the greatest value, suspect that the two largest values were somewhat greater than they ought to be. The expression (5) provides us with a test of this.

In actual fact we may not know whether we can assume that our n trial periods are all independent or not. Suppose we have $2n$ or $2n + 1$ observations. On the null-hypothesis that the observations are independently and normally distributed, it does not follow that if we take as our trial periods 2, 4, 6 . . . $2n$ units, the resulting n amplitudes will be distributed independently. However on this simple null hypothesis, R. A. Fisher has shown how the trial periods may be chosen, so as to satisfy the conditions.

We suppose that we have $(2n + 1)$ observations at unit intervals apart, and take for our trial periods $\frac{2n+1}{p}$ $p = 1, 2, \ldots n$.

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We fit

$$\bar{U}_r = A_p \cos \frac{2\pi pr}{2n+1} + B_p \sin \frac{2\pi pr}{2n+1} \quad . \quad . \quad . \quad . \quad (6)$$

directly to the observations by least squares.

We find

$$A_p = \sqrt{\frac{2}{(2n+1)}} \sum_{r=1}^{2n+1} a_{pr} u_r \qquad B_p = \sqrt{\frac{2}{(2n+1)}} \sum_{r=1}^{2n+1} b_{pr} u_r$$

where

$$a_{pr} = \sqrt{\frac{2}{(2n+1)}} \cos \frac{2\pi pr}{2n+1} \qquad b_{pr} = \sqrt{\frac{2}{(2n+1)}} \sin \frac{2\pi pr}{2n+1}.$$

It may be shown that the n sets of a's, the n sets of b's together with the set of coefficients which are simply $\sqrt{\frac{1}{(2n+1)}}$ repeated $(2n+1)$ times, form an orthogonal matrix. Hence the A's and B's are all independently and normally distributed with variance $2/(2n+1)$ Hence $A^2_p + B^2_p$ $p = 1, 2, \ldots n$ all have independent exponential distributions with mean $\frac{4\sigma^2}{N}$, $N = 2n+1$. Thus the conditions of the significance test are satisfied. Further

$$\sum_{p=1}^{n} (A_p^2 + B_p^2) = \sum_{r=1}^{2n+1} (u - \bar{u})^2$$

so that the modified Schuster criterion amounts to splitting up the sum of squares into n components of 2 d.f. as shown, and finding the distribution of the ratio of the largest component to the total.

If the number of observations is even, there is a slight complication.

We find

$$A_n = \sqrt{\frac{1}{n}} \sum_{r=1}^{2n} a_{nr} u_r \qquad B_n = \sqrt{\frac{1}{n}} \sum_{r=1}^{2n} b_{nr} u_r$$

where

$$a_{nr} = \sqrt{\frac{1}{n}} \cos \pi r \qquad b_{nr} = \sqrt{\frac{1}{n}} \sin \pi r.$$

Thus B_n vanishes and $A_n = \frac{1}{n}(u_1 - u_2 + u_3 \ \ldots \ u_{2n+1} - u_{2n})$. This is normally distributed with variance $\frac{2\sigma^2}{n} = \frac{4\sigma^2}{N}$ so $\frac{(A^2_n + B^2_n)N}{4\sigma^2}$ has a χ^2 distribution with 1 d.f., while $\frac{(A^2_p + B^2_p)N}{4\sigma^2}$ $p = 1, 2, \ldots (n-1)$ are distributed independently as χ^2 with 2 d.f., i.e. exponentially. We can only get $(n-1)$ independent amplitudes to test.

References

COCHRAN, W. G. (1941), *Ann. Eugen.*, **11**, 47–52.
FINNEY, D. J. (1941), *Ann. Eugen.*, **11**, 136–40.
FISHER, R. A. (1929), *Proc. Roy. Soc.*, A, **125**, 54–9.
—— (1940), *Ann. Eugen.*, **10**, 14–17.
—— and YATES, F. (1953), *Statistical Tables for Agricultural, Biological and Medical Research.* 4th ed. London: Oliver & Boyd.
GARWOOD, F. (1941), *J.R. Statist. Soc. Suppl.*, **7**, 65–77.
STEVENS, W. L. (1937), *Ann. Eugen.*, **8**, 57–73.
—— (1939), *Ann. Eugen.*, **9**, 315–20.
VERNON, P. E. (1936), *J. Educ. Psych.*, **27**, 1–17.
—— (1936), *J. Educ. Psych.*, **27**, 704–9.
—— (1936), *Psychological Bull.*, **33**, 149–77.
WHITWORTH, W. A. (1878), *Choice and Chance.* 3rd ed. Cambridge, University Press.
—— (1897). DCC *Exercises in Choice and Chance*, No. 667. Cambridge University Press.

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Discussion on Dr. Irwin's Paper

Dr. J. Wishart: We meet here the day before a massed battery of statisticians is due to face microphones and television cameras, and to operate an electronic computer by remote control, with a view to giving confident forecasts of the ultimate outcome of an event to which the laws of chance have at least some relevance. Doubtless it befits our status as a learned society that we should use our time to debate the number of ways in which the handwriting of a number of people can be randomly matched with their photographs, or the different types of cigarette cards that can be collected by a small boy—this last a purely academic exercise so far as I am aware, for it is a long time since such cards have been issued with cigarette packets. It would have been quite wrong, I fancy, to discuss the probable distribution, among k at present unoccupied seats, of n candidates of two or more kinds ($n > k$) so as to secure at most one candidate per seat in the final outcome.

Dr. Irwin's main point is that the Whitworth proposition which he quotes is of cardinal importance in providing easy derivations of certain frequency distributions. My own edition of *Choice and Chance* (2nd Ed., 1870) does not contain this proposition. I am glad, therefore, to have my attention drawn to it, but, this being so, I am inclined to advance the alternative point of view that the proposition does little more than carry us a step beyond the well-known formula for the number of combinations of n things taken r at a time. I would myself regard the chain of reasoning needed to solve the matching distribution problem, in the simple form quoted, as the same as that needed to prove the Whitworth proposition. The latter, on the other hand, seems to me to be only one step, and that not the most important one, in the problem of the distribution of the greatest interval on a line (Dr. Irwin's third case).

Incidentally, Dr. Irwin should have mentioned that copies of both *Choice and Chance* and *DCC Exercises* are now available in American reprints.

The simple matching problem is well-known. In Kendall's *Advanced Statistics* it is the problem of n letters placed at random in n envelopes (also relevant to election time), and it was a *Sunday Times* problem in 1952 concerning the distribution of card coincidences when two shuffled packs are turned over together. Many more references could, and perhaps should, have been given to the more general theory of matching. Mood in the United States worked out some quite complicated distributions in the general case, while the application of the theory to experiments in extra-sensory perception by Rhind and Soal, among others, is arousing much discussion at the present time.

On a small point, Dr. Irwin could have achieved a simpler result on p. 391 by working out the *factorial* moment generating function, as he did in his second problem. Putting $e^t = 1 + u$, it is found that the generating function agrees with e^u as far as the term in u^n, so that the $n - 1$ factorial cumulants beyond the first are zero, as for the Poisson series.

The second problem is usually formulated in text-books as the distribution among k boxes of n balls tossed at random into them, and the solution is exceedingly easy. I think, indeed, that the answer is to be found without further working in another Whitworth result, namely Proposition XXII (5th Ed., 1901). The interest here, obviously, is to go further and consider the chances associated with the different numbers of balls that may be in the occupied boxes. Dr. David considered in her book *Probability Theory* (p. 104) only the case of n less than k, an unnecessary restriction, but she pointed out that the term $\Delta^r (0)^n$ has to be broken down into its parts. It is here that combinatorial methods, the subject of quite a large part of Whitworth's *Choice and Chance*, can produce answers to some quite complicated questions, with the aid of tables of symmetric functions such as those of David and Kendall.

An interesting example of this kind is Schrödinger's problem of measuring the intensity of cosmic radiation. k counters are exposed to a cosmic ray shower and hit by n rays, a particular ray hitting one, and only one, counter. The solution Dr. Irwin gives is the well-known probability of precisely r counters going off. When the number has been observed it is then possible to estimate the intensity of the radiation.

It should be pointed out that the rth differences of the powers of zero have been known for a long time (though not so referred to by Whitworth in Proposition XXII), and tables were available long before those of Stevens to which Dr. Irwin has referred. See, for example, Whittaker and Robinson, *Calculus of Observations*, 1924, p. 7.

I have no doubt we all have our pet problems. One which has interested me is due to Laplace. r numbers (out of n different numbers) are randomly chosen, noted and returned. The probability is required that after s sets of drawings (of r numbers), at least t different numbers will have been seen. Dr. David gives the answer in her book (p. 108) as

$$\frac{\Delta^t\{(n-t)^{(r)}\}^s}{\{n^{(r)}\}^s} \qquad \left[\, {}^{(r)} = x(x-1) \ \ldots \ (x-r+1)\right]$$

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She applies this in the special case of a court of discipline drawn from four members, two of whom are chosen at random for any one sitting. The chance that in six sittings all four will have served is given by a series involving seven differences of the powers of zero, which requires the use of tables up to the twelfth order and a tedious calculation. But this is a case where an easier method can be found. The probability quoted, when worked out from first principles, may be expressed as

$$1 - \binom{t}{1}\left\{\frac{n-r}{n}\right\}^s + \binom{t}{2}\left\{\frac{(n-r)^{(2)}}{n^{(2)}}\right\}^s - \binom{t}{3}\left\{\frac{(n-r)^{(3)}}{n^{(3)}}\right\}^s + \ldots$$

If in this we put $n = 4$, $r = 2$, $s = 6$, $t = 4$ we get

$$1 - \binom{4}{1}\left(\frac{2}{4}\right)^6 + \binom{4}{2}\left(\frac{2.1}{4.3}\right)^6$$

$$= 1 - \frac{1}{16} + \frac{1}{7776} = 0{\cdot}9376$$

with the very minimum of calculation. I cite this as an example where use of differences of powers may not be the best way of answering a practical problem, although it provides a neat formula.

I have no comments to offer on the rest of Dr. Irwin's paper except to suggest, tentatively, that use of Whitworth's Proposition LVII (5th Ed., 1901) may possibly be worth exploring as a method of proof of the distribution of the greatest interval on a line. It is used in Kendall's *Exercises* (no. 87) to derive the mean interval, and the variance, when n points are taken at random on a line of given length.

If anyone is interested in really hard problems of a combinatorial character, which have not yet been solved, I commend to his attention an outstanding problem in run theory which the theoretical physicists would like to see solved, and of which I would gladly give particulars.

It is a pleasure to move a vote of thanks to Dr. Irwin for giving us this paper.

Dr. ISSERLIS: I am glad to have the opportunity of seconding the vote of thanks to Dr. Irwin for his paper. As an "old dog" myself I welcome his interesting applications of the series in Whitworth's *Choice and Chance* first published nearly eighty years ago. The series is a generalization of the well-known problem of the number of ways of putting u letters into n addressed envelopes and getting them all wrong. If there are n letters and m envelopes, n can be greater or less than m. During my two hundred mile journey from Devon to this meeting I wondered how Dr. Irwin's results could be applied to tomorrow's problem of fitting candidates into constituencies. It seems probable that there will be two empty compartments. All the applications are interesting and good illustrations of the method, but the fourth reminds me of my old suspicion of periodogram analysis. We arrange the observations in rows, add up the columns and look for bumps. The biggest bump corresponds to the principal period. The late Dr. Brownlee thought that he had proved in this way that differing types of measles were unable to cross the bridges over the River Thames. I have very great pleasure in seconding the motion.

The vote of thanks was put to the meeting and carried unanimously.

Dr. F. N. DAVID: It is a pleasure to say a few words about Dr. Irwin's paper, although the cut and dried nature of a combinatorial problem perhaps makes searching comment a little difficult. Dr. Irwin has interested himself in suggesting how the theorem which he ascribes to Whitworth may be interpreted in various statistical aspects. This theorem is itself a particular case of Macmahon's master theorem on permutations (Macmahon, *Combinatory Analysis*, Vol. I, p. 98). Macmahon applies his theorem to the "problème de rencontres" which is a version of the matching problem, the "problème des ménages", which is a variant of this, and the enumeration of Latin Squares, to mention only three of a large variety of applications. The generality of Macmahon's theorem is striking, but it is at least open to question whether generality of this kind in combinatorial problems is very useful. Experience usually shows that it takes as long to puzzle out how the theorem may be applied in any particular problem as it does to solve the problem by *ad hoc* methods.

The difficulty in ascribing any particular theorem to Whitworth lies in the fact that he gave no references to previous work by other authors. Since he was writing a test-book, this lack of reference is permissible, but it should not lead us to overlook the work of Sylvester or Morgan Crofton or, in this particular case, that of De Moivre and Laplace. The matching problem or the "problème de rencontres" or the special version, the game of Treize, was first, I think, stated and

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solved by Montmort, aided by Nicholas Bernoulli, in his *Essai d'Analyse sur les Jeux de Hazards* (2nd Ed., 1714). Incidentally, he also gives another use of Whitworth's theorem:

"n dice each have f faces marked from 1 to f. They are thrown at random.. Determine the number of ways in which the sum of the numbers exhibited is equal to p."

We require the coefficient of x^p in the expansion of

$$(x + x^2 + x^3 + \ldots + x^f)^n$$

which calls for the same combinatorial procedure as the theorem. However, Montmort was specialized in his statement. Not so De Moivre. We have (*Doctrine of Chances*, 1714, Problems 35 and 36):

Problem 35: "Any number of letters a, b, c, d, e, f, etc., all of them different, being taken promiscuously as it happens: to find the Probability that some of them shall be found in their places according to the rank they obtain in the alphabet and that others of them shall at the same time be displaced."

Problem 36: "Any given number of letters a, b, c, d, e, f, etc. being each repeated a certain number of times and taken promiscuously as it happens: to find the Probability that of some of those sorts, some one letter of each may be found in its place, and at the same time, that of some other sorts, no one letter may be found in its place."

Laplace uses balls stamped with numbers instead of letters, but he also achieves the theorem. Now De Moivre and Laplace did not see the various ways in which the theorem could be applied; neither, of course, did Whitworth: it was left to Dr. Irwin to do this. Both De Moivre and Laplace found the distribution of empty classes and both discuss approximations to the differences of zero. Karl Pearson was of the opinion that De Moivre's approximation was to be preferred over that of Laplace. He investigated the point when computing (with E. M. Elderton) a table of $\frac{\Delta^p 0^{p+s}}{(p+s)!}$ in 1925. This table is to be preferred over the later table of Stevens for certain types of probability problems. The tables of the normal integral can often be used effectively in this type of problem. I will illustrate on the distribution of r.

For $n = 10$, $k = 5$, the normal approximation (with a continuity correction) gives 0·057 for the probability of 3 or less boxes being occupied. For $n = 5$, $k = 128$, the normal approximation gives 0·061 for the probability of 4 boxes or less being occupied which, although some way from the 0·0745+ of the exact value, would not nevertheless lead to an error in the significance test since one must inevitably judge on whole numbers.

Dr. D. E. Barton: I should like to mention two points of interest arising out of the distributions Dr. Irwin has discussed.

Sir Ronald Fisher's g distribution has a peculiar limiting form. Thus it is easy to show that

$$\mathscr{E}(g^m) = \frac{n!}{(n+m-1)!} \{d/dt\}^m B(n, 1-t) \Big|_{t=0}$$

and in particular

$$\mathscr{E}(g) = \frac{1}{n} \sum_{r=1}^{n} \frac{1}{r}, \quad \text{Var. } g = \frac{1}{n(n+1)} \sum_{r=1}^{n} \frac{1}{r^2} - \frac{1}{n+1} \{\varepsilon(g)\}^2.$$

These two moments are special cases of a general form due to Dr. David who finds the moments of the ith interval length in order of magnitude. We are intending to publish a paper which includes these.

The standard form of g, i.e.

$$x = ng - \log n$$

has a characteristic function which may be shown to tend to $\Gamma(1 - it)$ as $n \to \infty$. Thus $2ne^{-ng}$ tends to be distributed as a χ^2 of two degrees of freedom. Unfortunately this limiting distribution is by no means reached for n as large as 50 and a larger n than this is seldom considered in practice.

A similar limit exists in the cigarette card problem. Thus if n cards are necessary to complete a set of k then the Laplace transform of the p.d.f. of n is

$$L(t) = \frac{k!}{k^k} \prod_{r=0}^{k-1} \left\{ e^t - \frac{r}{k} \right\}^{-1}$$

whence

$$\mathscr{E}(n) = k \sum_{r=1}^{k} \frac{1}{r}, \quad \text{Var. } n = k^2 \sum_{r=1}^{k} \frac{1}{r^2} - \mathscr{E}(n).$$

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It follows similarly that $2ke^{-n/k}$ tends to be distributed as a χ^2 of two degrees of freedom as $k \to \infty$. This incidentally demonstrates analytically the result that

$$\Delta^k 0^n \sim k^n(1 - ke^{-n/k}),$$

a modified version of the Laplace approximation mentioned by Dr. David.

I turn to my second point. Whitworth's theorem is a slightly specialized case of the earlier (and more general) theorem of Boole, namely, if $E_1, \ldots, E_k$ are a set of events which each may or may not occur, not necessarily independently, then

$$P\{\bar{E}_1, \ldots, \bar{E}_k\} = 1 - \sum_{r=1}^{k} P\{E_r\} + \sum_{r<s}^{k} P\{E_r, E_s\} - \ldots$$

In this more general form a wider body of theory is unified. In particular I should like to mention a theorem of Feller in the field of recurrent events which follows, I think, more simply as a corollary of Boole's theorem.

Thus, if at the stages $1, 2, \ldots, r, \ldots$ of a process, an event A may or may not occur, with probabilities P_r and $1 - P_r$ and if p_r is the probability of the first event A occurring at the rth stage then it follows from Boole's theorem that

$$p_k = P_k - \sum_{r+s=k} P_r P_s + \ldots, \qquad k = 1, 2, \ldots$$

If we express this in terms of generating functions we have Feller's relation

$$\{1 + \sum_{k=1}^{\infty} P_k z^k\}\{1 - \sum_{k=1}^{\infty} p_k z^k\} = 1.$$

The process is assumed to be Markovian in that an event A having occurred the process starts again *de novo*.

Dr. J. O. Irwin (in reply): It has been a great pleasure to me to listen to the contributions which have been made to the discussion. I must particularly thank Dr. Isserlis for the kind things he said. It is a pleasure in these days that a paper which, though it embodied a good deal of thought, and was put together somewhat quickly, should provoke a long discussion. I think it was Lord George Hamilton who once said it was a good thing that every now and then this Society should have a paper on a subject which no one understood. Had this subject been presented in his time, or even in times more recent than that, it might have satisfied his criterion. Now, however, that I have seen how deep is the degree of learning of some Fellows of this Society I feel almost regretful at having produced something so elementary.

The following contribution was received in writing after the meeting:

Mr. J. C. Tanner: I should like to give a simple geometrical proof of equation (2) in section 3 of the paper, which states that there is a probability $(1 - rg)^{n-1}$ that r intervals x_i, selected from n on a line of length u, are all greater than or equal to ug.

Consider the n-dimensional sample space $(x_1, x_2, \ldots x_n)$. The distribution of the n intervals is uniform over that part of the $n - 1$ dimensional hyperplane $x_1 + x_2 + \ldots + x_n = u$ for which each $x_i \geqslant 0$. The required probability is therefore the proportion of the area of this region for which the r restrictions $x_i \geqslant ug$ are satisfied. Each such restriction reduces the linear size of the region (i.e. the range of value which can be taken by any x_i) by ug, without altering its shape. With r restrictions, therefore, the linear size of the region is reduced from u to $u - rug$, and thus its area is reduced to a proportion $(1 - rg)^{n-1}$ of its initial value.

Dr. Irwin subsequently contributed the following written addendum.

I mentioned one or two topics at the meeting which had not been incorporated in the printed paper and I should like, if I may, to put these on record.

Section 1. "The matching distribution can, of course, test only whether the judges are or are not doing anything more than guessing. If it is desired to try and measure the degree of success attained in matching, other and more elaborate methods must be used. The earlier literature did not always distinguish between these two aims and some incorrect methods were used largely in

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consequence of this. In particular a contingency table method was used, at first incorrectly. The table below may serve as an example.

Personality Sketches

		D	*A*	*C*	*B*	*Total*
Handwriting records	1	(18)	7	0	7	32
	2	4	(7)	21	0	32
	3	7	18	(6)	1	32
	4	3	0	5	(24)	32
Total		32	32	32	32	128

(The correct matchings are in brackets.)

"This table, taken from Vernon, shows 4 handwriting records matched against 4 personality sketches by 32 judges. The earliest workers at this kind of problem calculated a χ^2 or a coefficient of mean squared contingency for the whole table. This was clearly wrong, because the procedure could throw light only on the consistency of the judges not on their correctness. I think P. E. Vernon was the first to see this. He suggested getting over the difficulty by pooling the diagonal and non-diagonal frequencies and then calculating χ^2. This gives

$$\chi^2 = \frac{N(\bar{x}-1)^2}{t} = \frac{(\bar{x}-1)^2}{(1/n)} = \frac{(D-n)^2}{n} = \frac{(55-32)^2}{32} = 16{\cdot}53$$

with

$$N = 128 \qquad t = 4 \qquad n = 32$$

"(Here D is the total and $\bar{x}$ the mean number of correct matchings, out of the n made.)

"Thus the procedure is clearly equivalent to comparing with its variance the deviation of the number of correct matchings from expectation.

"This is perfectly satisfactory as a significance test, but Vernon went on to calculate $C_2 = \sqrt{\frac{\chi^2}{(N+\chi^2)}}$ and used this as a measure of success in matching. I do not think we should now regard this as a satisfactory procedure. Incidentally Vernon had a slip in his χ^2 (he had $t-1$ in the denominator instead of t). So far as I know, the first correct solution of the problem of obtaining a significance test for the diagonal frequencies in this kind of test was given by Stevens. He was dealing with matching problems in parapsychology and considered a somewhat more general problem than this one. The problem of measuring the degree of success is still, I think, an open one. Professor Kendall's coefficient of concordance, again, would give a measure of the consistency of the judges but not of their accuracy. Perhaps a regression method rather like that described by Dr. Daniels a few years ago, of relating a ranking or rating to the true order might also be used here. I think this would lead to the mean value of the Spearman rank correlation coefficient for the different judges, as a measure of accuracy of matching."

Section 2. Before reading this section I said, "I am old-fashioned enough always to think of the distribution described in Section 2, as the cigarette card distribution. It was indeed suggested to me that I could more appropriately call it the tea-card distribution after a brand which issues pictures of film stars. But after all the subjects of cigarette cards were often instructive and I prefer instruction to glamour. At any rate my conservatism triumphed; I suppose that *that* too to-day must be regarded as a matter of controversy". (This in itself should provide an answer to Dr. Wishart's earliest criticism, just as the previous paragraphs partly anticipated a later one.) "It is of course true that the genetical application is the interesting one here. I should like to have said a great deal more about Stevens's genetical application, but in view of the limited time available, I must refer you to his paper. Incidentally, his modification of the scoring method, when there are small differences in probability between the different judges, is especially ingenious."

Section 4. After reading this section I said, "I introduced this section because I have found that students often find it difficult to understand the reason for the choice of these particular trial periods. I think modern writers, for example Professor Fisher and Professor Bartlett, would agree that it is no use having more trial periods than the number of independent comparisons that can be made among the observations and that if we calculate more they are not all independent and in fact yield no further information.

"My attention was drawn to the subject again very recently, because Mr. Gower has recalculated the Beveridge periodogram on an electronic computer and used precisely these trial periods.

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"However, the earlier writers on periodogram analysis, including Beveridge himself, selected their trial periods on a different principle. Beveridge used 304 trial periods with about 300 observations. He always arranged that the number of observations used was an integral multiple of the trial period. The trial period was thus a fraction r/s, and the total number of observations was $N = mr$. This facilitated the arithmetic as his observations could be written down in m rows of r observations, and there were s cycles in each row, ms altogether. For instance, Beveridge's first trial period was 2 years with $N = 300$. This is straightforward. His second is $\frac{84}{41} = 2{\cdot}049$ years. So $m = 4$, $N = 336$, $ms = 164$. His next five trial periods were

$$\frac{76}{37}, \frac{68}{33}, \frac{60}{29}, \frac{56}{27}, \frac{52}{25},$$

i.e. 2·054, 2·061, 2·069, 2·074, 2·080 with $N = 304, 340, 300, 336, 312$. They go on like this until $\frac{24}{11}$ i.e. 2·218 with $N = 288$. Then we have

$$\frac{22}{10}, \frac{20}{9}, \frac{52}{23}, \frac{16}{7}, \frac{44}{19}, \frac{7}{3},$$

i.e. 2·200, 2·222, 2·261, 2·286, 2·316, 2·333 with $N = 308, 320, 312, 320, 308, 308$. The choice of periods was thus determined by the need for arithmetical facility."

The contributions of Dr. Wishart, Dr. David, Dr. Barton and Mr. Tanner to the discussion are all clarifications or amplifications of the subject-matter of the paper. With some of these I was already familiar, but I am grateful for them all.

As a result of the ballot taken during the meeting, the candidates named below were elected Fellows of the Society:

Gyaw Pyu Aung.
Raymond Arthur Walter Connor.
William Stafford McPhee.
Douglas William Maitland.
Peter Alan Mawson.
Ivor John Smith.
George Warden.

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Colliery Statistics

By F. D. K. Liddell

PAGE
1. Introduction 405
2. The Colliery Profile 406
3. The Diverse Nature of the Coal Industry 407
4. Size and Performance 410
5. Measuring Performance 412
6. Summary and Conclusions 413

1. *Introduction*

The British coal industry was nationalized in 1947, and by 1949 the National Coal Board, the single "owner", had assumed responsibility for the collection of official statistics. This was a major change, for previously returns were made by each of the colliery owners direct to the Government Department concerned. The position has been described by the Board's Chief Statistician (George, 1949), but it is helpful here to consider it in the light of its historical development.

Neff (1932) provides perhaps the earliest coal statistics with a series of coal prices extending over four centuries which tells us, incidentally, that in 1547 coal could be bought in Newcastle at rather less than a shilling a ton. But such series come from a myriad of sources: they are not continuous nor can they be expected to be comparable over time. The first regular series of information was produced in the middle of the nineteenth century and referred to production (Hunt, 1854). In this period, too, coal mining became the subject of legislation, concerned mainly with sociological improvement—in 1842 restrictions were made on child labour; in 1872 an Act was concerned mainly with safety, health and management, and the legislation between 1887 and 1896 was "in the first instance, dictated by that humane and anxious solicitude of the safety, comfort and well-being of those engaged in labour" (Williams and Pitt-Lewis, 1896)—which required for the first time the maintenance of certain records. In 1928 Dron reported that "one by-product of the troubles of late years is the fact that very full and accurate statistics of the output, costs and profits of the coal trade are now available." Indeed, from 1873 onwards there has been a steadily increasing flow of statutory returns.

Before nationalization the management of the industry was in the hands of hundreds of different organizations, each responsible for one or two or at the most a dozen or so collieries. Each management naturally had its own views on the need for statistics in its own particular task and, inevitably, the systems of recording in existence were legion. Statistics were being collected primarily so that the general development of the industry, particularly in relation to safety and conditions of employment, might be watched. The only statistics common to all collieries were the statutory returns, and none of these had been initiated for the purposes of management as such.

The colliery is the natural unit both of production and of management, and it is, therefore, statistics relating to the colliery as a unit that are necessary to a unified industry, to help the Board in planning, developing and watching the progress of the industry. But the figures which are readily available are for fairly large groups of collieries. Normally they are published for National Coal Board Divisions, which are 9 in number and embrace up to 186 collieries each, or occasionally for National Coal Board Areas, of which there are some 50, numbering up to 40 collieries each.

Where aggregates and averages are of figures which show wide variation between individuals they conceal as much as they should reveal. If collieries had similar characteristics and behaved similarly, this would matter little. But, in fact, the variation between collieries is great. Early in the last century a Select Committee of the House of Commons (1835) reported that "the great dissimilarity of the mineral stratification of the Kingdom and the constantly varying circumstances of particular mines render it, in their opinion, impossible at present . . . to form any rule of universal application", and this state of affairs has been maintained to such an extent that recently the Chairman of the Coal Board (Houldsworth, 1953) remarked on the "astonishing manner" in which the performance of individual pits varies and drew the conclusion that "in a sense, there is no industry: there are statistically only nine hundred pits". A simple example of the extent of

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the variation is given in the only distribution of mines published by the Ministry of Fuel and Power (1955, p. 75). This shows all the collieries in Great Britain distributed according to their size (numbers of men employed) and their productivity (output per manshift worked) in 1953. The very small mines, employing under about 30 men, are normally worked not by the National Coal Board but under licence. But even without these the variation in size is seen to be from under 20 men to over 3,000. And in each size group the variation between collieries in productivity is very large: in most groups there are some collieries with a productivity of under 15 cwts per manshift and others producing 40 cwts or more per manshift—about three times as much.

Evidence of variation between collieries within a Division, or even an Area, was available internally from routine statistics and from *ad hoc* studies, and there thus appeared to be ample reason for a study of figures relating to individual collieries. In 1952, certain routine work on data for the previous year could be handled as well on punched-cards as otherwise, and the opportunity was taken to punch some eight leading figures of output, productivity, costs, etc., on to a single card for each colliery. These cards were found to be extremely useful and provided *inter alia* much of the detailed information on which an important paper (Houldsworth, 1953) was based. For information relating to 1952 it was possible to expand considerably. Much useful and interesting information was gleaned from the study of these figures. They were used not only for examining broad patterns of behaviour, but also for the choice of samples of collieries for particular studies which demanded either "representative" pits or pits with certain characteristics. Further expansion took place for the data relating to 1953, and the Colliery Profile, as it had been christened, for that year is described in the next section.

2. *The Colliery Profile*

As with much research work, economy was essential and, for this still experimental stage, it was decided to use only data which were readily available and to make no attempt to collect new information from the collieries. This meant that certain factors which it would have been desirable to include were omitted, but in view of the large number of items which were available and the scope which they gave for investigation this was not considered a serious drawback. Naturally, it was felt desirable to collect in one exercise all that was likely to be of any use for the study contemplated, so many sources of information had to be tapped.

Preliminary work had shown that there were many difficulties in making comparisons between collieries and it was hoped to evade some of them by making comparisons over time. Figures were therefore assembled giving not only the levels of certain variables in 1953, but also indicating how they had changed from previous years.

Since the intention was to look for general patterns of behaviour and for deviations from such patterns, codes and indicators of performance were quite adequate and no attempt was made to achieve accounting accuracy for the figures used. For many of the variables only a single column code was necessary, and in no case were more than three columns used.

A complete list of the information punched is given in the Appendices and some comments are given below. The Reid Report (Ministry of Fuel and Power, 1945) contains a description of mining methods and a glossary of mining terms, which may be found useful.

Appendix A deals with the main body of information. In section I we recorded the Colliery's "planning classification"—whether scheduled to be closed or to be reconstructed or to carry on more or less as before. Section II concerns characteristics of the pit, mainly in terms of its organization. As indications of the methods of raising and of working in use, we recorded only the predominant method. A colliery in which no gas has been reported may work with naked lights, but otherwise safety lamps have to be used, and we recorded which category each colliery fell into. As an indication of the complexity of the underground lay-out, we recorded the total length of roads. We also indicated whether mine cars, horses or man-riding were in use at the particular colliery. Section III deals with the manpower at the colliery, and its distribution and supervision. The only figures of manpower available in this detail referred to the last week of the year. Since the number of surface workers depends greatly on the amount of coal cleaning, and on many other factors, it was decided to record the distribution of workers underground by expressing face workers as a percentage of all underground workers, and to relate surface workers to the same figure. Section IV is concerned with the simpler measures of performance. The figures of shifts

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worked include work beyond the normal hours. Although productivity is often measured in terms of output per manshift, the inverse of this measure, manshifts per ton of output, has the considerable advantage that the figures for different places of work can be added up to give an overall figure. A measure of productivity which takes attendance into account is output per man over the year; keeping in line with the other productivity figures, we recorded man-years per ten thousand tons. Section V deals with financial data and Section VI with earnings, injuries and disputes. These last three factors have been grouped together since they are all of "socio-logical" interest.

Two subsidiary sources of information have also been used. The first is concerned with methods of working and transport underground, the second mainly with the characteristics of the coal produced. The Ministry of Fuel and Power require a summary of methods of working and transporting coal, which is compiled from colliery returns, of which Appendix B is typical. By tracing the components of the total output through the various tables it is possible to discover the detailed methods of mining employed at the particular colliery. A separate card for each component of the Colliery's output has been punched giving the tonnage and coding the methods of working, getting, loading, face transport, gate transport and main transport. It was not always possible to sort out all the components, where streams merge and then divide again, but fortunately this has not proved a major drawback in practice. It is normal for several seams to be worked at one colliery and there is, for another purpose, a punched card for each seam giving the output from that seam and certain information about the coal which includes the ash content, average thickness of coal worked and the total thickness from roof to floor. From this information it is possible to determine such items as the predominant working thickness at each colliery or the weighted average ash content of the total production.

For the bulk of the data, where there is one card for each colliery, a count of cards is also a count of collieries and so a Counting Sorter automatically produces a distribution of collieries according to any of the punched variables. Since the information ran on to two Hollerith cards, the use of a Reproducer was necessary, as described by Yates (1949, p. 112).

Because of the great variation in size between collieries, much of the study has been within size groups. Since most of the rates punched are rates per ton of output, the measure of size used for this grouping was the total output.

3. *The Diverse Nature of the Coal Industry*

We should naturally expect the method of working at a colliery to affect its performance. Each of six stages of mining—working, getting, loading, face transport, gate transport and main transport—can be tackled in various different ways, but at each stage there is a predominant method. The state of affairs is shown in Table 1. We might expect from this that there will be a "standard"

TABLE 1

Methods of Working, Getting and Moving Coal, 1953

Stage	*Working*	*Getting*	*Loading*	*Face Transport*	*Gate Transport*	*Main Transport*
Predominant method, with percentage of output got with this method	Longwall, 90%	Coal cutters, 72%	Hand loading, 94%	Conveyors, 90%	Conveyors, 88%	Tubs or cars, 79%
Predominant combinations of methods, with percentage of output got with them	Coal cutters in longwall faces, 68%					
		Coal cutters, hand loaded to face conveyors, 67%				
				Conveyors in face and gate, 87%		
					Conveyors to tubs or cars, 67%	

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method which combines the particular predominant components (i.e., longwall, coal cutters, hand loading, conveyors in face and gate, and tubs or cars in main roads). The aggregate figures, however, do not tell us how predominant this method is. Conceivably 67 per cent. of the coal got might be by this method, since this is the least of the percentages; the "expected" amount won by the "standard" method, found by multiplying the proportions in the various components together, produces an estimate of (·90 × ·72 × ·94 × ·90 × ·88 × ·79 × 100 =) 38 per cent. A closer examination of the cards for each method described above reveals that the tonnage produced by the "standard" method is in fact 41 per cent., and is won from 324 collieries. Not all these pits use this method alone, however: indeed some 254 have other methods of mining, leaving only 70 which use solely the "standard" method. Indeed for the industry as a whole the number of collieries which use only one method throughout is 175 out of 890,* and these pits account for only 10 per cent. of output. In other words most pits have at least two methods; and since the difficulties of comparing pits using different methods are obvious, the complications are considerable.

Different methods of mining are by no means the only sources of variation in performance. We can illustrate this by considering those pits within an Area which are using the same methods. The following tables are based on 15 pits from a particular Area which is more productive than average and which in 1953 ran at a substantial profit. The choice of Area was arbitrary, but the variation found is not atypical. These pits all use the longwall method of working, the majority of coal from each of them is produced in the "standard" way of machine cutting and hand-loading on to conveyors, and they all wind their coal up the shaft by cages.

TABLE 2

Output and Manpower of 15 *Collieries in Area A*, 1953

(*a*) Output (thousand tons):

148	303	390	451	632
223	375	419	463	952
286	380	420	491	971

(*b*) Manpower:

420	960	1,070	1,240	1,340
480	960	1,150	1,240	2,530
880	970	1,210	1,260	2,640

In Table 2 (*a*), we find the distribution of these collieries by output: the smallest output is only 148 thousand tons a year and the largest is 971 thousand tons. This variation is, of course, very great. Table 2 (*b*) gives the distribution of the pits according to their manpower: the smallest pit employed only 420 men and the largest 2,640. The variation from the largest to the smallest in manpower is very nearly the same as it is with output and so it would appear at first sight that differences in the number of men are sufficient to account for the variation in output. We would therefore expect that the productivity per man of the pits would be more or less constant. Table 3

TABLE 3

Productivity of 15 *Collieries in Area A*, 1953

(Manshifts per thousand tons)

At the face	180	210	230	240	250	250	250	250
Elsewhere	340	300	420	390	370	440	450	520
Overall	520	510	650	630	620	690	700	770
At the face	260	260	260	260	280	280	300	
Elsewhere	360	380	410	460	410	480	430	
Overall	620	640	670	720	690	760	730	

* Certain collieries were excluded from this study because of major changes taking place there.

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gives the distribution of manshifts per thousand tons worked at the face and elsewhere, and the 15 pits are seen to vary in their productivity, at the face, from 180 manshifts per thousand tons in the best case to 300 in the worst, and elsewhere, from 300 to 520. Productivity at the face and elsewhere is seen to be associated; pits which have high productivity on the face tend also to have high productivity elsewhere, and *vice versa*, although the association is not universal.

The other pits in the Area have productivities both well below and well above the extremes of the 15 examined here, the standard deviation of overall productivity being 185 compared with 76. But although concentration on the "standard" method of mining has done something to reduce variability, it is still very wide not only in productivity but also for other variables. Some examples are given in Table 4. Many of the pits had a profit similar to that of the whole Area,

TABLE 4

Profit or Loss, Costs, Supervision and Injuries at 15 Collieries in Area A, 1953

a) Profit or loss (shillings per ton):

Profits:	+14	+6	+5	+2	*Losses:*	−0
	+13	+6	+3	+1		−2
	+7	+5	+3	+0		−13

(*b*) Costs (shillings per ton):

Wages	22	25	26	28	28	29	29	29
Other	20	22	23	21	27	23	24	28
Total	42	47	49	49	55	52	53	57
Wages	30	30	31	31	31	32	33	
Other	24	25	22	25	27	23	25	
Total	54	55	53	56	58	55	58	

(*c*) Underground supervision ratio (officials per thousand men):

48	57	68	75	77
50	64	69	75	80
56	65	70	75	89

(*d*) Injuries (absences of four days or more per hundred thousand shifts worked):

Underground	100	110	120	120	130	130	130	140
Surface	25	30	31	38	24	37	44	28
Underground	140	140	140	150	160	160	160	
Surface	41	49	64	45	22	28	39	

roughly 3*s*. per ton; but the range is from a profit of 14*s*. per ton to a loss of 13*s*. per ton. Further, the costs of production vary widely, with wages costs ranging from 22*s*. per ton to 33*s*. per ton, and other costs from 20*s*. per ton to 28*s*. per ton. Again, the proportion of supervisory staff—overmen, deputies, shotfirers, etc.—varies from 4·8 per cent. of the total underground labour force to nearly double, 8·9 per cent. Lastly, the injury rates (expressed as the number of absences, due to injury, of four days' duration or longer, as a rate per 100,000 manshifts worked) vary underground, from 100 to 160, and on the surface from 22 to 64. Incidentally, this Area is not typical in that there is no apparent relation between the two rates; in most Areas we have found that those pits which have a low rate of underground injuries tend also to have a low rate of surface injuries.

Another way in which diversity between pits is noticeable is in their change of performance from one year to another. The simplest example is of their change in output. Table 5 gives the distribution of 625 collieries, excluding drift mines, in five size groups, according to the change in their output in 1952 compared with 1951 and in 1953 compared with 1952. The complete range of change is not indicated here since even when dealing with pits which are reputedly without major change either in organization or in manpower from one year to another it is still not unknown to find variation of over 30 per cent. either up or down. What is clear from Table 5 is

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TABLE 5

Distribution of Collieries by Changes in Output, 1951–53

Size Group Outputs (Thousand Tons, 1953)	*Output in* 1953 *Compared with* 1952	*Output in* 1952 *Compared with* 1951: *Decrease of* 7½% *or more*	*Change of less then* 7½%	*Increase of* 7½% *or more*	*Total*
Less than 100	Decrease of 7½% or more	15	21	8	44
	Change of less than 7½%	6	19	15	40
	Increase of 7½% or more	6	7	5	18
	Total . . .	27	47	28	102
100 to 199	Decrease of 7½% or more	12	27	8	47
	Change of less than 7½%	11	40	19	70
	Increase of 7½% or more	7	16	6	29
	Total . . .	30	83	33	146
200 to 349	Decrease of 7½% or more	4	20	7	31
	Change of less than 7½%	12	75	27	114
	Increase of 7½% or more	4	16	9	29
	Total . . .	20	111	43	174
350 to 699	Decrease of 7½% or more	1	16	5	22
	Change of less than 7½%	10	83	23	116
	Increase of 7½% or more	4	13	4	21
	Total . . .	15	112	32	159
700 and over	Decrease of 7½% or more	0	2	1	3
	Change of less than 7½%	2	30	3	35
	Increase of 7½% or more	1	3	2	6
	Total . . .	3	35	6	44
All	Decrease of 7½% or more	32	86	29	147
	Change of less than 7½%	41	247	87	375
	Increase of 7½% or more	22	55	26	103
	Total . . .	95	388	142	625

that there is no trace of association from one year to another. A pit's performance in one year apparently gives no indication of the way in which it will perform in another year. There are some pits which improve steadily, some which deteriorate steadily and some which go up and down and this is true whatever the size of pit. However, the proportion which remains very similar in output from one year to another differs radically from one size group to another. Out of the 625 pits considered, 247 (or just under 40 per cent.) remained with their output within ±7½ per cent. in each year but the percentage of such pits in the five size groups increases steadily from 19 per cent. (19 out of 102) amongst the smallest collieries to 68 per cent. (30 out of 44) amongst the largest. This comparative steadiness of large pits is not confined to output but appears common for most measures of performance.

4. *Size and Performance*

Much, indeed, has been said about the effects of size on performance—see, for example, Acton Society Trust (1953)—and the Colliery Profile gives us a means of examining them further. We use the data for the 625 collieries, excluding drifts, and consider performance measured in terms of productivity, costs, injuries and disputes. The average performance of the pits within each of five size groups is given in Table 6. Productivity, wages costs and non-wages costs all improve steadily from the smaller collieries to the larger, but these improvements in material performance

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TABLE 6

Productivity, Costs, Injuries and Disputes by Size of Colliery, 1953

Size Group Outputs (Thousand Tons) of	*Number of Collieries in Group*	*Productivity at the Face (Manshifts per Thousand Tons)*	*Costs (shillings per ton)*		*Injuries, Underground (Absences per 100,000 Shifts)*	*Disputes (Tonnage Lost as Percentage of Total Output)* (median)
			Wages	*Other*		
Less than 100 .	102	462	44	35	126	0·8
100 to 199 . .	146	416	39	31	153	1·2
200 to 349 . .	174	345	33	28	154	0·9
350 to 699 . .	159	290	31	25	158	0·9
700 and over .	44	240	28	23	168	0·9

are accompanied by a deterioration in injury rates. On the other hand, the percentage of tonnage lost through disputes is no greater in the larger pits than in the smaller ones, which is perhaps surprising, since any effects of size are likely to be due to management or to morale and disputes might appear to be a not unreasonable index of morale.

Size for its own sake cannot be expected to cause differences in productivity and in costs, and it would be reasonable to expect some associated factors to be involved. Table 7 gives the average

TABLE 7

Working Thickness, Mechanization, Supervision and Shotfiring by Size of Colliery, 1953

Size Group Outputs (Thousand Tons) of	*Number of Collieries in Group*	*Working Thickness (Inches)*	*Mechanization (Special Scale)*	*Supervision Underground (Officials per Thousand Men)*	*Shotfiring (Shots per Ton)*
Less than 100 . .	102	42	3·1	74	5·8
100 to 199 . .	146	45	3·4	66	4·9
200 to 349 . .	174	50	3·6	68	4·5
350 to 699 . .	159	50	3·9	63	4·2
700 and over . .	44	56	4·3	58	3·2

thickness of seams, mechanisation, supervision ratio and shotfiring rate for the various size groups. Each of these factors is seen to be associated with size to some extent. Since shotfirers are included as supervisors in the calculation of the supervision ratio, it is not surprising that there should be an association between the supervision ratio and the shotfiring rate. Indeed, we find, in the more detailed breakdown of Table 8, that the associations of both size and supervision with shotfiring are very clear. We would similarly expect the degree of supervision to have some effect

TABLE 8

Shotfiring Rates by Size of Colliery and Supervision Ratio, 1953

(Shots fired per ton of output)

Size Group Outputs (Thousand Tons) of	*Supervision Ratio, Underground (Officials per Thousand Men)*		
	Less than 55	55 *to* 85	*Over* 85
Less than 100 . .	3·05	5·61	7·82
100 to 199 . . .	1·98	5·51	8·00
200 to 349 . . .	1·71	5·06	6·85
350 to 699 . . .	2·39	4·84	6·32
700 and over . . .	1·81	4·29	6·00

on dispute rates and, when we examine Table 9, giving the tonnage lost in collieries classified according to their supervision ratios, the correspondence is striking.

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TABLE 9

Supervision Ratios and Disputes, 1953

Supervision Ratio, Underground (Officials per Thousand Men)	*Tonnage Lost by Disputes (Percentage of Total Output) (median)*
Less than 45	2·9
46 to 55	1·9
56 to 65	1·9
66 to 75	0·9
76 to 85	0·8
86 to 95	0·7
Over 95	0·6

Thus we have found size to be associated with many other variables, and for these to be interrelated themselves. Indeed so many factors are involved in any consideration of size that a simple size effect is unlikely. Only Table 8, of the last five, gives any indication of the variation within size groups. However similar variation does exist with most variables and it should be emphasized that, even within comparatively small size groups, there is seldom homogeneity, despite a tendency to treat size as a variable of major importance.

5. *Measuring Performance*

A most difficult problem is to find a reliable measure for general use of a colliery's performance. There are many possible measures which can be used for different purposes. High productivity is an obvious criterion, but it does not necessarily mean high efficiency since it is closely related to geological conditions and to the degree of mechanization. We have already seen in Tables 3 and 4 that there is an association in one Area between wages costs and non-wages costs and also between manshifts per thousand tons at the face and elsewhere. This state of affairs is common—the association of wages costs and non-wages costs in 1951 was illustrated by Houldsworth (1953). There are also associations between other measures of performance but they are by no means complete.

TABLE 10

Criteria of Performance, 1953

Variable	*Criterion of "Good" Colliery*	*Collieries Included as "Good" on*			
		This Criterion Alone		*These Criteria Together*	
		Number	*Per cent.*	*Number*	*Per cent.*
Change in output, 1953 compared with 1952	Increase of 2½% or more	282	34	282	34
Face productivity, 1953	295 shifts per thousand tons or less	287	35	119	14
Change in face productivity, 1953 compared with 1952	Improvement of over 2½%	279	34	79	10
Productivity elsewhere, 1953	495 shifts per thousand tons or less	333	40	62	7
Change in productivity, elsewhere, 1953 compared with 1952	Improvement of 7½% or better	212	26	26	3
Injury rate, underground, 1953	Less than 120 absences per 100,000 shifts	211	25	9	1

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In Table 10, six measures are considered. For each of them we have divided the distribution of collieries as close to the quartile as practical, whilst ensuring always that more than 25 per cent. of collieries were included as "good" on the single criterion. Thus, of the 830 collieries under consideration, 34 per cent. and 35 per cent. would be counted "good" on the first two criteria alone, i.e. on a good increase in output or on high productivity at the face. But when they have to satisfy both these criteria the proportion of "good" collieries drops to 14 per cent. Even if the two criteria had been entirely unrelated, 12 per cent. of collieries would have survived. Improvements in productivity are a little more closely related to the level of productivity—i.e., the collieries which are highly productive per man tend to improve their productivity more rapidly than others—and after five successive criteria have been met, 26 collieries still remain. However, when a comparatively low injury rate is added as a criterion, 17 of these collieries fail. Indeed, were the rather different measure, coal quality, to be added, none of them would survive at all.

It is clear that no single measure of performance can be applied in every situation. The choice of a measure depends on the particular investigation and its aims.

6. *Summary and Conclusions*

In this paper we have tried to explain some of the difficulties involved in the interpretation of coal statistics and how they are being overcome. Collieries are so diverse in their nature that any study of their performance is handicapped severely. A rise in the aggregate output, for example, does not mean that most pits have produced more, but only that the balance of increases and decreases is positive. The reasons for such changes in the performance of individual collieries may be legion and widely different action may be required to get general improvement. With the raw material now available in the form of the "Colliery Profile" and with the tools which we are learning to use the reasons for the very wide variations in performance can be analysed and the statistical problems of the industry should become more tractable.

Acknowledgments

I should like to express my thanks to the National Coal Board for permission to publish this paper. The opinions expressed are not, however, necessarily those of the Board. Most of the tabulations and basic work connected with the Colliery Profile have been performed by Mr. W. B. Wakefield and to him I owe a special debt of gratitude.

APPENDIX A

Information Punched on the Colliery Profile, 1953

	Units, etc.
I. LOCATION, etc.	
Division and Area.	
Planning classification	Classification and whether opening, closing, etc.
II. ORGANIZATION.	
Method of raising	Skip, cage or drift (predominant method).
Method of working	Longwall, room and pillar, or other (predominant method).
Lights	Naked or safety.
Degree of face mechanisation	Special scale.†
Shot-firing: Rate	No. fired per 10 tons of output.
Weight of explosive	Pounds per 10 shots.
Length of roads	Thousand yards.
Mine cars	Tens.
Horses	Whether used.
Manriding	Whether used.
Cleaning	Special scale.†
III. MANPOWER.	
Total at 2nd January, 1954	Ten men.*
Changes 1953 cf. with 1952 1952 cf. with 1951 1953 cf. with 1951	5 per cent.*
Distribution of labour: Face cf. with all underground	Per cent.*
Surface cf. with all underground	Per cent.*
Supervision: Underground officials cf. with all underground workers	Per mill.*
Surface officials cf. with surface workers	Per mill.*

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APPENDIX A—*cont.*

IV. PERFORMANCE.

Shifts worked: Face, Elsewhere, Overall	Shifts per man per year.*
Output, 1953	Thousand tons saleable.
Changes 1953 cf. with 1952, 1952 cf. with 1951, 1953 cf. with 1951	5 per cent.
Productivity: Face, 1953	Manshifts per hundred tons.
Changes 1953 cf. with 1952, 1952 cf. with 1951, 1953 cf. with 1951	5 per cent.
Elsewhere, 1953	Manshifts per hundred tons.
Changes 1953 cf. with 1952, 1952 cf. with 1951, 1953 cf. with 1951	5 per cent.
Overall, 1953	Manshifts per hundred tons.
Changes 1953 cf. with 1952, 1952 cf. with 1951, 1953 cf. with 1951	5 per cent.
(*Long term*) Face, Elsewhere, Overall	Man years per ten thousand tons.*

V. COSTS AND RESULTS.

	Units, etc.
Costs: Wages	Shillings per ton.
Changes 1953 cf. with 1952, 1952 cf. with 1951, 1953 cf. with 1951	Per cent.
Non-wages—	Shillings per ton.
Changes 1953 cf. with 1952, 1952 cf. with 1951, 1953 cf. with 1951	Per cent.
Total—	Shillings per ton.
Changes 1953 cf. with 1952, 1952 cf. with 1951, 1953 cf. with 1951	Per cent.
Profit or Loss (including Surplus Export Proceeds)	Shillings per ton.
Changes 1953 cf. with 1952, 1952 cf. with 1951, 1953 cf. with 1951	Shillings.

VI. EARNINGS, INJURIES AND DISPUTES.

Earnings per manshift	Shillings.
Injuries: Underground	Number of absences of 4 days or more per ten thousand manshifts worked.
Surface	Number of absences of 4 days or more per hundred thousand manshifts worked.
Disputes:	Number
Tonnage lost	Per thousand tons of output

* Based on manpower at 2nd January, 1954.

† Special scales: *Mechanisation.*

Average, weighted by tonnage, scoring:

Ploughs, etc.	9
Cutter Loaders	8
Cutter & Picks	5
Cutters	4
Picks	1
Handgot	0

Cleaning.

Average, weighted by tonnage, scoring:

Washed	9
Hand or dry cleaned	7
Froth flotated	7
Untreated	0

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APPENDIX B

TYPICAL COLLIERY RETURN OF THE GETTING AND MOVEMENT OF COAL

Tonnage of Coal Got, (R & W) by Method of Working and Getting (*Calendar Year* 1953)

Tons

	Method of Getting						
	Mechanical Picks						
	Alone (a)	With Coal Cutters (b)	Coal Cutters (excl. (b)) (c)	Meco Moore Cutter Loaders (d)	Ploughs, Strippers, Gloster Getters, Joy Continuous Miners, etc. (e)	Hand Got (f)	Total (g)
Method of Working: 1. Longwall	9,838		4,744				14,582
2. Room and Pillar						2,667	2,667
3. Other methods (*to be specified*)							
4. Total	9,838		4,744			2,667	17,249

Method of Loading to Face or Room Transport by Method of Getting

Tons

	Method of Loading to Face Transport					
	Power Loaded to:			Hand Loaded to:		
	Conveyors (a)	Shuttle Cars (b)	Tubs/Cars (c)	Conveyors (d)	Tubs/Cars (e)	Total (f)
Method of Getting: 1. Mechanical Picks alone				9,838		9,838
2. do. with Coal Cutters						
3. Coal Cutters (excl. 2)				4,744		4,744
4. Cutter Loaders						
5. Ploughs, Strippers, etc.						
6. Hand Got					2,667	2,667
7. Total				14,582	2,667	17,249

Method of Gate or Intermediate Transport, i.e. on gate or subsidiary roads only

Tons

	Tonnages from Face Transport as per Table 8 (g)		Method of Gate Transport				
			Transfer from Face Transport to:			Total Gate Transport (h)+(i)+(j) (k)	Tonnages passing direct from Face to Main Transport (l)
			Conveyors (h)	Shuttle Cars (i)	Tubs/Cars (j)		
Method of Face Transport 8. Conveyors	Item 7(a)+7(d)	14,582	14,582			14,582	
9. Shuttle Cars	7(b)						
10. Tub/Cars	7(c)+7(e)	2,667			2,667	2,667	
11. Total	7(f)	17,249	14,582		2,667	17,249	

Method of Main Transport, i.e. on all trunk or main roads

Tons

	Tonnages arriving through Gate Transport as per Table 9 items 11(h), (i), (j) and (k) (m)	Tonnages arriving direct from Face Transport as per Table 9, Column (1) (n)	Method of Main Transport		
			Transfer from Gate or Face Transport to:		Total Main Transport (o) + (p) (q)
			Conveyors (o)	Tubs/Cars (p)	
Method of Arrival at Main Transport (from Gate or Direct from Face Transport) 12. Conveyors	Item 11(h)	Item 8(l)		14,582	14,582
13. Shuttle Cars	11(i)	9(l)			
14. Tubs/Cars	11(j)	10(l)		2,667	2,667
15. Total	11(k)	11(l)		17,249	17,249

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References

ACTON SOCIETY TRUST (1953), *Size and Morale*. London.
DRON, R. W. (1928), *The Economics of Coal Mining*. London: Arnold.
GEORGE, R. F. (1949), *J.R. Statist. Soc. A.*, **112**, 331–337.
HOULDSWORTH, Sir H. (1953), *The Pits of Britain*. Manchester: Manchester Statistical Society.
HOUSE OF COMMONS (1835), *Report of Select Committee on Accidents in Mines*, Paper 603. London.
HUNT, R. (1854), *Mineral Statistics of the United Kingdom*. London: Geological Survey.
MINISTRY OF FUEL AND POWER (1945), *Coal Mining* (Cmd. 6610). London: H.M.S.O.
—— (1955), *Statistical Digest*, 1954. London: H.M.S.O.
NEFF, J. U. (1932), *The Rise of the British Coal Industry*. London: Routledge.
WILLIAMS, B. F. & PITT-LEWIS, G. (1896), *The Coal Mines Regulations Acts*, 1887–1896. London: Butterworth.
YATES, F. (1949), *Sampling Methods for Censuses and Surveys*. 1st ed. London: Griffin.

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An Analysis of 162,332 Lottery Numbers

By John H. West

The Randomization Apparatus and Procedure

The Southern Rhodesian lotteries are conducted four times a year before a large audience in Salisbury, the draw being made through the medium of lettered or numbered balls moving inside six revolving cages.

The balls are made of red rubber and are 84 millimetres in diameter and 0·45 kilograms in weight. The letter or number imprinted on each ball is 70 millimetres high, but the depth of the impression is too small to be measured without special instruments. The balls are tested by hand for bounce and examined by eye for defects before each lottery, and continue in use as long as they appear satisfactory to the Director of State Lotteries. However, as soon as even one ball shows sign of wear and tear the whole set of over fifty balls is replaced by a new set. Any set of balls differs slightly, though quite visibly, from any other set in colour, texture, indentation of numerals, smoothness, etc., and, of course, balls from the same set also differ from each other, though not to the same extent as balls from different sets. Different sets of balls behave differently in the cages; the current set, being very smooth and bouncy, take much longer to come out of the cages than did the last set, which were matt finished and less bouncy.

Balls are allotted by a member of the staff randomly to the cages at the start of each lottery, and occasionally the Director, as an added precaution, transfers a few balls between cages just before the draw starts. Moreover each lottery lasts, with intervals, three days, and each evening the balls are taken out, cleaned with methylated spirits, and inserted, again at random, into the cages.

At the present time the first cage contains a ball for each of the letters A, B, C, D, . . . and represents the first letter on the lottery tickets. The number of such letters, of course, depends on the number of tickets sold. The second cage contains a ball for each of the letters A to H, and represents the second letter on the tickets.

The third cage contains ten balls numbered 0 to 9 and represents the first digit on the tickets. The fourth, fifth and sixth cages also each contain ten balls numbered 0 to 9, and represent the second, third and last digits on the tickets. When the third, fourth, fifth and sixth cages each produce 0 simultaneously, however, this is taken as 10,000.

Each cage is shaped like a flat cylinder and is 40 in. in diameter and 18 in. wide. Its axis is mounted horizontally on ball bearings and contains a hole big enough to insert the balls. The sides of the cage consist of spokes made of chromium plated bars $\frac{3}{8}$ in. thick and 2 in. apart at the circumference. The circumference side is made of similar bars fixed parallel to the axis. The circumference side is split down the middle, thus dividing the cage into two halves. The axis of the cage is supported by a steel framework and is 5 ft. above the floor. At the back of the framework is the electric motor, reduction gear and a chain drive which turns the axis, causing the two halves to spin in opposite directions. Inside the circumference side of each half cage are ten equally spaced lugs. They are 2 in. high at the side of the cage and taper down until they are flush with the edge of the half cage. It is these lugs which impart a lively movement to the balls during revolution.

During the whole period of each lottery the cages are rotating at a constant speed of thirty revolutions per minute. At a faster speed the balls would tend to be carried round fixed to the same spot by centrifugal force. At a slower speed they would tend to bounce lethargically at the bottom of the cage. At thirty revolutions per minute, with eight to ten balls in a cage, they bounce about inside the whole cage without frequently moving over the axis. To draw a prize number the controller in charge of the six cages presses a lever which causes the rear half of each cage to move backwards about 5 in. The balls are prevented from falling through the space thus created,

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by a chromium plated bar-and-steelplate framework which embraces the whole circumference. At the lowest point of the circumference there is a hole in the steelplate just large enough to take one ball. After a second or so a ball duly falls into the hole and in so doing trips a lever which operates a cam to close the two halves together again, and also allows the selected ball to roll forward to a wire box in front of the cage where its number can be easily seen. An operator in charge of each cage then displays for the benefit of the audience a large card containing the number of the ball selected. The numbers thus displayed are checked by the controller, who examines each ball and calls out the letters and numbers.

Sometimes, though infrequently, the same number is drawn more than once during a lottery, in which case the ticket holder receives only the (larger) prize corresponding to the first time. It much more often happens that a number is drawn corresponding to an unsold ticket. To keep such numbers to a minimum, arrangements are made for the tickets sold to form an unbroken series from AA0,001 to whatever the last number may be. In the September, 1952, lottery, for example, 723,900 tickets were sold and the last ticket was therefore LA3,900, the letters I and J not being used to avoid the possibility of confusion. All numbers drawn from LA3,901 to LH9,999 therefore corresponded to unsold tickets.

Statistical Records Available

No records have been kept of the life of balls. The latest set lasted only two lotteries, but this was unusual, and a duration of three or four lotteries is believed to be more common. Obviously the size of the lotteries has an important bearing on the life of the balls, and in the early years, when the lotteries were much smaller than they are now, balls are believed to have lasted up to eight lotteries. During the War the usual balls could not be obtained from France and although the substitutes, which were of synthetic and not natural rubber, soon showed obvious signs of wear, they had to continue in use for a long period—certainly more than eight lotteries.

Except for the very first lottery a record has been maintained of the number of occasions on which each letter and each digit has turned up in each lottery, and these records were made available to the writer. They cover every ball which turns up during the whole period of each official draw, including numbers corresponding to unsold tickets, and numbers which turn up more than once. The total therefore exceeds the total number of prizes distributed, and as an example of what this involves the September, 1952, lottery may be mentioned again; there were 1,719 "prizes" 114 "not solds" and 0 "repeats".

As there have always been four cages, each with ten balls representing the ten digits, whereas there have been different numbers of balls representing the letters, and in the early stages only one letter cage, it was decided to confine the analysis of these records to the digits only.

Results for the Thousands Cage

To reduce to simpler proportions the mass of figures for the 67 sets of results which were available when this paper was started, the data for the Thousands cage were first totalled cumulatively from lottery number 2 to lottery number 68, thus producing a long table of 67 lines. From this table every fifth line was extracted to form a sample as far as possible unaffected by seasonal factors, as might have been the case if, say, every fourth line had been taken. As 67 is not exactly divisible by 5 the first extract was made at lottery number 8 and thus gave the cumulative totals of the first seven available results. The summary table was then converted into percentage form by expressing each actual cumulative frequency as a percentage of the corresponding theoretically expected cumulative frequency, the latter of course being one-tenth of the number of times all the digits turned up. The cumulative percentages correct to one decimal place and the cumulative expected frequencies correct to the nearest whole number are shown in Table 1.

This table suggests a downward bias in digits 4 and 8 which remain consistently below the expected value, and an upward bias in digit 9 which after the first 7 lotteries is consistently above the expected value. Although digit 8 appears to have a consistent bias it ends up only 1·7 per cent. below the expected value, whereas digit 5, which fluctuates about the expected value in a random manner, ends up 2·1 per cent. below.

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TABLE 1

Cumulative Results for the Thousands Cage

Lotteries up to and Including Number	*Expected Value*	1	2	3	4	5	6	7	8	9	0
		Cumulative Number of Times above Digit Turned Up, Expressed as a Percentage of the Expected Value									
8	257	110·5	100·8	101·2	95·0	98·9	104·7	95·0	97·3	96·2	101·2
13	471	105·9	96·5	104·3	93·3	100·7	102·2	97·2	99·1	104·0	97·5
18	668	106·0	96·7	101·9	95·8	100·2	101·3	98·7	96·2	103·3	99·9
23	848	101·4	99·6	103·5	92·7	99·4	100·5	97·1	97·6	108·5	99·6
28	1,049	101·2	100·2	102·3	95·4	99·5	99·5	96·0	95·7	107·2	103·6
33	1,262	99·9	100·1	102·3	97·8	100·4	98·0	96·2	95·3	105·7	104·4
38	1,515	100·2	99·8	103·1	99·1	100·4	97·1	97·6	94·3	107·0	102·4
43	1,802	101·7	100·6	102·9	96·4	99·7	97·5	97·5	93·9	107·5	102·7
48	2,108	101·9	99·4	101·8	97·1	99·0	96·1	98·5	94·3	107·7	104·0
53	2,472	102·0	98·3	102·4	97·9	100·3	95·7	97·7	95·8	106·3	103·9
58	2,915	100·8	99·0	101·9	99·0	100·0	96·0	98·0	96·1	105·1	104·5
63	3,490	100·6	100·3	98·9	97·8	100·0	98·5	98·3	97·4	104·5	104·2
68	4,058	100·4	98·5	98·7	96·9	97·9	99·2	100·0	98·3	106·0	104·1

Results for the Hundreds Cage

The data relating to the Hundreds cage were treated in the same way as those of the Thousands cage and the results are given below:

TABLE 2

Cumulative Results for the Hundreds Cage

Lotteries up to and Including Number	*Expected Value*	1	2	3	4	5	6	7	8	9	0
		Cumulative Number of Times above Digit Turned up, Expressed as a Percentage of the Expected Value									
8	257	105·9	92·2	92·6	104·7	94·2	91·8	114·4	104·2	92·6	107·8
13	471	107·4	97·4	99·0	97·0	95·0	93·9	108·6	103·3	96·5	102·4
18	668	104·7	95·1	96·9	96·7	99·5	99·3	103·7	103·0	101·3	100·1
23	848	105·4	94·2	100·2	95·6	98·9	100·1	101·2	103·0	101·5	101·6
28	1,049	105·3	94·4	100·6	97·2	100·9	98·6	99·7	100·9	100·2	102·8
33	1,262	104·7	95·7	100·4	96·5	102·3	97·8	99·5	99·9	100·2	103·7
38	1,515	104·5	96·0	101·2	96·4	103·0	96·1	100·6	99·0	99·3	104·3
43	1,802	103·6	96·7	100·8	97·3	102·3	95·5	101·0	98·9	99·9	104·1
48	2,108	102·0	99·2	101·3	99·0	102·0	93·1	100·5	99·2	100·0	104·0
53	2,472	100·8	99·1	101·1	100·5	103·3	93·2	98·6	99·5	100·6	103·7
58	2,915	99·1	98·0	101·0	99·5	104·0	93·2	98·9	100·8	100·8	105·3
63	3,490	100·2	96·5	98·1	98·1	102·2	96·0	100·0	102·0	99·3	107·8
68	4,058	99·2	96·4	97·3	97·7	101·2	96·1	102·6	102·6	100·6	106·3

Not only does digit 0 appear 6·3 per cent. more than the expected grand total but it is above the cumulative expected value at every point shown in the above table. The table also shows that there is a consistent downward bias in digit 2, which remains below the cumulative expected value at every point and ends up 3·6 per cent. below. The largest grand total downward bias occurs in digit 6 which ends up 3·9 per cent. below the expected value, but this digit is not consistently below expectation and the trend in the last score of lotteries is towards the expected value.

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Results for the Tens Cage

A summary of the results relating to the Tens cage is given below:

TABLE 3

Cumulative Results for the Tens Cage

Lotteries up to and Including Number	*Expected Value*	1	2	3	4	5	6	7	8	9	0
		Cumulative Number of Times above Digit Turned Up, Expressed as a Percentage of the Expected Value									
8	257	102·0	102·7	107·3	104·7	95·3	93·0	98·5	92·5	103·9	100·3
13	471	102·2	103·5	105·0	103·7	98·2	99·2	100·1	93·8	100·4	94·4
18	668	104·6	101·4	104·0	101·0	101·3	98·6	99·0	95·5	98·3	96·4
23	848	105·2	100·4	102·5	102·0	101·8	101·2	99·1	95·4	95·3	96·7
28	1,049	104·0	101·4	105·4	100·0	101·5	100·1	97·3	95·3	98·5	97·0
33	1,262	105·0	100·8	104·2	100·5	103·0	99·6	94·8	95·9	98·3	98·5
38	1,515	104·5	101·4	106·7	100·8	102·0	98·3	96·3	95·4	97·6	97·3
43	1,802	105·3	100·2	105·2	100·6	101·6	97·2	98·2	95·9	98·6	97·5
48	2,108	105·8	101·4	105·6	99·0	100·9	96·9	98·6	96·3	98·9	96·9
53	2,472	104·3	101·6	103·9	99·7	102·2	96·0	98·5	96·5	100·0	97·9
58	2,915	104·0	100·5	103·4	98·8	102·0	96·5	98·5	96·3	100·4	99·4
63	3,490	103·2	99·4	100·8	97·2	102·6	95·8	99·6	98·4	100·5	100·8
68	4,058	102·9	98·5	100·4	96·6	101·7	96·6	101·6	98·0	101·2	102·5

Digit 4 over the whole series of lotteries turns up 3·4 per cent. less than would be theoretically expected, but this is not a consistent bias, as up to the 43rd lottery the cumulative total is above expectation. Digit 8 is the only one in the above table to show a consistent downward bias at every point to which the figures are accumulated, but the last ten lotteries show an upward movement towards the expected value. Digits 1 and 3 show a similar movement in the opposite direction, the cumulative totals being consistently above expectation, and the last fifteen lotteries showing a strong downward tendency towards the expected value.

Results for the Units Cage

The following table shows a summary of the results for the Units cage.

TABLE 4

Cumulative Results for the Units Cage

Lotteries up to and Including Number	*Expected Value*	1	2	3	4	5	6	7	8	9	0
		Cumulative Number of Times above Digit Turned Up, Expressed as a Percentage of the Expected Value									
8	257	104·7	90·5	106·2	99·6	105·1	104·7	91·4	103·1	89·1	105·8
13	471	103·3	96·3	101·2	110·0	100·0	106·6	92·3	97·9	93·2	99·2
18	668	100·4	97·1	100·2	108·9	100·3	104·2	94·7	99·6	93·7	101·1
23	848	101·6	96·8	99·9	104·3	102·2	102·5	95·7	100·4	96·6	100·0
28	1,049	100·6	97·5	101·1	104·5	98·6	100·7	97·0	102·4	97·6	100·0
33	1,262	101·3	99·0	101·8	106·0	98·0	99·8	95·4	101·8	97·7	100·1
38	1,515	101·2	99·0	102·3	106·0	97·3	99·0	95·4	100·4	98·5	100·8
43	1,802	101·6	98·0	101·7	107·3	97·8	97·3	96·2	101·5	98·3	100·5
48	2,108	102·0	98·5	101·8	106·8	98·9	96·1	95·5	101·6	98·3	99·5
53	2,472	102·9	98·7	103·0	106·3	98·9	94·8	96·4	99·9	99·1	100·3
58	2,915	101·8	98·2	103·1	105·1	99·4	95·5	96·5	100·1	99·1	100·5
63	3,490	102·0	98·0	100·4	102·6	100·5	97·0	96·8	101·8	99·3	101·1
68	4,058	102·0	97·2	100·6	102·1	101·1	98·2	98·0	99·7	99·9	101·2

Digits 2, 7 and 9 exhibit consistently low values at every point in the above table, though in the case of digits 7 and 9 the most recent lotteries show a strong upward tendency towards the

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expected value. Digit 1 is the only one which shows consistently high percentages throughout the above table though digits 3 and 4 record high values at all but one point. Digit 6 fluctuates considerably about the expected value, varying between 6·6 per cent. above and 5·2 per cent. below expectation, and the final cumulative value of 1·8 per cent. below expectation cannot really be considered as significant.

Results for all Cages Combined

So far the results have been considered in relation to the individual cages, with the implicit assumption that any bias is due to (*a*) some characteristic of the cage which tends to make it select too frequently or too seldom a particular digit, or (*b*) some characteristic of the balls bearing a particular digit which causes them to fall through the trap door of a particular cage more often or less often than the average, or (*c*) some combination of (*a*) and (*b*). The analysis has isolated very provisionally a few cases in which certain digits show bias in certain cages. It is of course quite impossible to isolate the results for a particular ball over a series of lotteries or even throughout one group of lotteries, because the balls are allotted randomly to the cages and are also renewed from time to time. Certainly each column and possibly each percentage in the tables therefore relates to several balls and not to a particular one.

It remains, however, to consider the case in which bias may be due to some characteristic of the impression of a particular digit on the four balls concerned. Thus it is conceivable that the hook in a figure 1 could tend to catch the lugs in the cages with the result that balls bearing this digit would be constantly bounced about with a very small chance of falling through the trap door, or the loops in a figure 8 could tend to slide off the lugs and so increase the chance of these balls falling through the trap door. The extent to which this occurs may be surmised from the analysis given in the following table.

TABLE 5

Cumulative Results for all Cages Combined

Lotteries up to and Including Number	*Expected Value*	1	2	3	4	5	6	7	8	9	0
		Cumulative Number of Times above Digit Turned Up, Expressed as a Percentage of the Expected Value									
8	1,028	105·8	96·5	101·7	100·9	98·3	98·5	99·7	99·3	95·4	105·7
13	1,883	104·7	98·3	102·9	100·9	98·4	98·7	99·5	98·4	98·9	98·9
18	2,670	103·8	97·5	100·7	100·5	100·3	100·9	99·0	98·5	99·1	99·4
23	3,393	103·4	97·7	101·6	98·7	100·6	101·1	98·3	99·2	100·2	99·2
28	4,196	102·7	98·3	102·3	99·1	100·1	99·7	97·5	98·5	100·8	100·8
33	5,049	102·7	98·9	102·2	100·2	101·0	98·7	96·4	98·2	100·5	100·7
38	6,060	102·7	99·0	104·0	100·6	100·7	97·6	97·6	97·3	100·6	101·2
43	7,209	103·0	98·8	102·7	100·5	100·4	96·9	98·1	97·5	101·0	101·2
48	8,433	102·9	99·5	102·6	100·4	100·2	95·5	98·2	97·9	101·3	101·5
53	9,890	102·4	99·4	102·6	101·1	101·2	94·9	97·7	97·9	101·4	103·7
58	11,658	101·5	98·9	102·4	100·7	101·4	95·3	98·0	98·3	101·5	102·5
63	13,959	101·6	98·4	99·6	98·9	100·4	96·9	98·7	99·7	101·0	103·8
68	16,233	101·1	97·7	99·3	98·3	100·4	97·5	100·5	99·6	101·9	103·5

This table shows a consistent downward bias in digits 2 and 8 and a consistent upward bias in digit 1. Digit 2, however, approaches very near the expected value by the 48th lottery and ends up only 2·3 per cent. below, while digit 8 is never more than 2·7 per cent. below and ends up only 0·4 per cent. below. After being 5·8 per cent. too high in the earlier lotteries digit 1 progresses fairly steadily towards the expected value and ends up only 1·1 per cent. above. The largest final deviation is shown by digit 0 which ends up 3·5 per cent. above expectation though the cumulative results up to the 23rd lottery were below.

Other Tables

Other tables were prepared for each cage showing the results expressed in deviations from the expected value, and also summaries of deviations amounting to 10 per cent. or more of the expected

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value. These were compiled for each group of five lotteries, but for economy of space are not reproduced here as they exhibit broadly the same kind of pattern as is commented on above.

Significance Tests

It might be expected that such a precision-made system of cages would satisfy all tests of randomness. As a first step it might be assumed that the 40,583 balls drawn up to date in each cage constitute a sample from an infinite population containing equal numbers of balls of each digit. On this basis, the average value per ball in the population would be 4·5 and the sample average, according to the theory of random sampling, should not differ from this by more than (say) twice the standard error. The averages for each cage and for all cages combined, together with their standard errors, have been calculated and are shown below:

TABLE 6

Average Results of 67 *Lotteries*

Cage	*Average Value Per Ball*	*Standard Error*	*Deviation of Average from Expectation*	*Ratio of Deviation to Standard Error*
Thousands cage	4·5065	0·0150	+0·0065	0·43
Hundreds cage	4·5018	0·0150	+0·0018	0·12
Tens cage	4·4824	0·0150	−0·0176	1·17
Units cage	4·4830	0·0150	−0·0170	1·13
All cages	4·4934	0·0075	−0·0066	0·88

From the above table it seems reasonable to conclude that so far as the arithmetic average is concerned the lotteries behave strictly in accordance with the theory of random sampling.

Turning now to the question of distribution, the next step is to apply the χ^2 test, where $\chi^2 = \Sigma\frac{(0-E)^2}{E}$ in which 0 is the observed frequency of a particular digit and E is the expected frequency, i.e., one-tenth of the total number of balls which turn up in a cage.

The following table shows the value of χ^2 for each lottery.

TABLE 7

Value of χ^2 *for each Lottery*

Lottery Number and Year	*Number of Balls Drawn per Cage*	*Value of* χ^2			
		Thousands Cage	*Hundreds Cage*	*Tens Cage*	*Units Cage*
2	359	10	7	4	14
3	344	9	7	10	16
4 1936	362	5	12	6	7
5	389	12	7	7	16
6	396	10	12	7	7
7	356	5	14	4	10
8 1937	365	4	9	10	18
9	442	6	4	4	11
10	453	20*	12	7	13
11	421	11	4	10	7
12 1938	397	9	17	10	9
13	423	9	9	8	9
14	409	18*	9	11	16
15	367	9	11	6	11
16 1939	366	8	9	8	4
17	390	7	9	7	14
18	436	11	14	16	10
19	372	49**	11	5	15
20 1940	292	9	7	2	6
21	369	14	12	9	6

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TABLE 7 (*Continued*)

Value of χ^2 *for Each Lottery*

Lottery Number and Year	*Number of Balls Drawn per Cage*	*Value of* χ^2			
		Thousands Cage	*Hundreds Cage*	*Tens Cage*	*Units Cage*
22 } 1941	369	9	8	10	10
23	405	15	13	15	11
24	410	10	24**	15	16
25	391	7	5	7	7
26 } 1942	415	22*	12	17	13
27	353	17	15	8	2
28	438	18*	11	16	8
29	364	6	19*	16	11
30 } 1943	385	15	19*	5	9
31	450	10	12	2	13
32	464	10	12	11	12
33	471	11	5	7	5
34 } 1944	481	7	20*	6	15
35	518	15	6	10	3
36	478	6	6	9	3
37	518	7	7	14	10
38 } 1945	532	8	3	11	6
39	551	7	2	4	11
40	552	3	3	3	5
41	589	7	8	7	11
42 } 1946	597	8	6	12	6
43	583	15	8	11	4
44	577	13	11	7	18*
45	638	9	10	18*	6
46 } 1947	622	5	18*	10	13
47	609	11	18*	8	6
48	615	6	12	16	17
49	682	11	10	10	5
50 } 1948	695	5	6	6	8
51	697	10	17	15	7
52	717	24**	6	5	13
53	850	11	20*	10	9
54 } 1949	847	12	11	18*	13
55	851	12	22*	3	6
56	855	12	10	12	5
57	871	10	9	9	15
58 } 1950	997	19*	19*	9	14
59	1,116	32**	20*	26**	18*
60	1,048	7	17	22*	13
61	1,266	21*	35**	18*	33**
62 } 1951	1,299	17	62**	34**	20*
63	1,023	14	33**	26**	14
64	1,114	32**	3	38**	27**
65	1,118	37**	15	17	20*
66 } 1952	1,079	32**	16	7	17
67	1,082	28**	38**	6	21*
68	1,293	21*	25**	21*	7

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A standard set of χ^2 tables gives the value at the 1 per cent. level of significance as 22, and at the 5 per cent. level of significance as 17. These are based on nine degrees of freedom because there are ten cells (one for each digit), nine of which can be independently fitted when the total is given. In the above table values of χ^2 above that for the 5 per cent. level of significance are marked with an asterisk. Values above that for the 1 per cent. level are marked with two asterisks.

It is apparent that the table can be divided into two distinct portions and a summary of results for these two portions is given below.

TABLE 8

Summary of Number of Asterisks Marked in Table 7

Portion	*Type of Asterisk*	*Thousands Cage*	*Hundreds Cage*	*Tens Cage*	*Units Cage*	*Totals*
Lotteries No. 2 to 51	Single	4	5	1	1	11
	Double	1	1	—	—	2
Lotteries No. 52 to 68	Single	3	4	4	4	15
	Double	6	5	4	2	17
	Total	14	15	9	7	45

In the early portion there are only eleven single asterisks and two double asterisks out of 200 tests, and this is about what would be expected in accordance with sampling theory. In the later portion, however, there are fifteen single asterisks and seventeen double asterisks out of 68 tests, which is considerably more than would be expected. As there are an average of 454 balls per cage in the early portion and 1,025 in the later portion it would appear that an increase in the value of χ^2 is associated with an increase in the number of balls drawn per lottery. The summary also shows that the best results, in the sense of non-significant χ^2, are given by the Units cage (only seven significant results), closely followed by the Tens cage (only nine significant results), while the Thousands cage (fourteen significant results) and the Hundreds cage (fifteen significant results) bring up the rear.

It would, of course, be interesting to examine results for much smaller numbers of balls drawn, particularly in the later portion of the lottery, to see what pattern of χ^2 results would emerge. Unfortunately counts of balls drawn are only made for complete lotteries and this is therefore impossible.

Another set of tests based on χ^2 may be made by accumulating the frequencies from the first lottery onwards and calculating χ^2 for each cage. In this way, it can be shown that the 12,623 balls per cage up to lottery number 33 produce values of χ^2 as follows: Thousands cage 13, Hundreds cage 10, Tens cage 13, Units cage 10. After the 33rd lottery values of χ^2 greater than 17 appear to an increasing extent in the accumulated figures. This may be contrasted with the state of affairs exhibited in Table 7, in which significant values of χ^2 do not appear to any marked extent until after the 50th lottery, i.e., about the 20,000th ball drawn. The value of χ^2 for the whole series of 67 lotteries is as follows: Thousands cage 31, Hundreds cage 39, Tens cage 21, and Units cage 10. It may be said, therefore, that the Units cage comes out of the test with flying colours, whereas the other cages produce results which are statistically significant of imperfect randomness.

Further light may be shed on the possible association between values of χ^2 and number of balls drawn, by means of correlation coefficients. To this end, the original (not the rounded) values of χ^2 and corresponding number of balls drawn were each numbered in ascending order of size and a coefficient of rank correlation was calculated, with the results shown below.

TABLE 9

Association between χ^2 and No. of Balls Drawn

Cage	*Correlation Coefficient*	*Standard Error*	*Ratio of Correlation Coefficient to Standard Error*
Thousands	+0·35	0·12	3·0
Hundreds	+0·32	0·12	2·7
Tens	+0·44	0·12	3·7
Units	+0·30	0·12	2·5

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By conventional standards, the above table indicates a significant degree of positive correlation between the value of χ^2 and the number of balls drawn. The correlation is greatest in the Tens cage and lowest in the Units cage, but the differences are comparatively small.

Although correlation appears to exist it is doubtful whether even the greatest coefficient, 0·44 is large enough to justify any very positive conclusions other than that as far as distribution is concerned the results of the lotteries are not entirely in accordance with statistical theory.

As a supplement to the χ^2 test an analysis of variance may be made on the cumulative totals for all 67 lotteries. These totals, less the cumulative expected total of 4,058, are shown in the following table, after which the results of the analysis of variance are given.

TABLE 10

Summary of Results of all 67 *Lotteries*

Digit	*Thousands Cage*	*Hundreds Cage*	*Tens Cage*	*Units Cage*	*Totals*
1	+ 17	− 35	+117	+ 79	+178
2	− 61	−147	− 60	−109	−377
3	− 52	−109	+ 14	+ 23	−124
4	−127	− 96	−140	+ 86	−277
5	− 88	+ 48	+ 67	+ 45	+ 72
6	− 33	−157	−138	− 72	−400
7	0	+106	+ 66	− 85	+ 87
8	− 68	+105	− 81	− 12	− 56
9	+246	+ 26	+ 54	− 7	+319
0	+166	+259	+101	+ 52	+578
Totals	0	0	0	0	0

TABLE 11

Analysis of Variance

Source	*Sum of Squares*	*Degrees of Freedom*	*Variance*
Between digits	219,403	9	24,379
Residual	194,821	30	6,494
Total	414,234	39	—

The analysis shows that the ratio of the variance between digits to the residual variance is 3·8. A table of F shows that, for nine degrees of freedom for the greater variance and thirty degrees for the lesser, this lies at a level of significance of under one per cent. The analysis of variance therefore confirms the evidence of the χ^2 test that the differences between the cumulative frequencies are hardly ascribable to wholly random causes.

Conclusion

The numbers which have turned up most often so far have been 9 in the Thousands cage, 0 in the Hundreds cage, 1 in the Tens cage, and 4 in the Units cage, but of course we cannot assume that No. 9014 has won most prizes, because digit 9 in the Thousands cage might have turned up most frequently with, say, digit 2 in the Hundreds cage, and no count has been made of the frequency of occurrence of each four-digit number so as to determine the most popular one.

The figures presented indicate that the rectangular frequency distribution with which we are concerned conforms with theory in respect of its average but not in respect of its shape. Evidence has also been brought forward to suggest that the non-comformity in respect of shape is linked to the size of the distribution, but it is not easy to suggest reasons why there should exist a significant difference between digits associated with the number of balls drawn. On the figures available it is moreover quite impossible to determine the proportions in which the differences are ascribable to the balls and to the cages.

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Some people have suggested that the balls should be tested and replaced more often, but the writer finds it difficult to accept this suggestion. What sort of tests could be devised that would set limits to all the elements of variability, and how could such limits be determined? Surely it is better to place reliance on the randomization procedure rather than to seek for absolute uniformity, which, even if attainable, would only last for an hour or two, and would inevitably increase the already high cost of the balls. The argument that balls should be replaced more frequently seems particularly untenable when one sees from Table 7 that the war-time results, when inferior balls were used for unusually long periods, were much better from the statistical point of view than the results of recent lotteries when the finest available balls were used with frequent changes.

In any case it should not be presumed that the results are entirely attributable to the balls. Although the cages are as near perfect as possible, it has been known, for example, for a drop of oil to appear on the axis, and this might affect the behaviour of a particular ball. Again, who knows what microscopic scratches and cracks may exist in the lugs or the spokes and have an affinity for some minute projection on a particular ball.

It could be argued that each ball should be marked and a record kept of the cage into which it was put so that the total variance could be split into the part due to the cages and the part due to each ball. The difficulty here would be that a distinctive mark or colour might affect the behaviour of the balls in the cages and might also conduce to a systematic allotment of balls to cages. Moreover, any results would only be applicable to the two or three lotteries representing the life of one set of balls.

Clearly some accumulation of minute factors has been at work to produce the results shown in the tables, but this investigation has failed to isolate any particular cause. The object of the paper, however, has not been to make an evaluation of the reasons why the lotteries should produce these particular results, nor to make any recommendations for remedial action. The object has simply been to explain an elaborate randomizing apparatus and to use well known statistical techniques to compare the distribution of over 160,000 digits with what would be theoretically expected.

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Statistical Assessment of the Need for Clinical Services

Report of a Working Group*

Preamble

In the Summer of 1952, the Committee of the Study Circle on Medical Statistics decided to supplement its normal programme of monthly meetings by setting up several small working groups for the study of specific problems. This report represents the work of one such group, which first met early in 1953 and reported to the Study Circle on April 27th, 1954.

The Existing Position

1. In Great Britain, the passing of the National Health Service Act (1946) has made it possible to plan the medical services more effectively than in the past. The problem of assessing the needs of the population in this respect has therefore become a matter of more immediate importance.

2. The study group has accordingly endeavoured to produce a report of practical value to planners, even though it may contain nothing of technical interest to statisticians. While assessment has been considered with particular reference to the need for hospital in-patient accommodation in England and Wales, it is recognized that similar problems have to be faced in assessing the need for specialist out-patient, general practitioner and local authority health services.

3. One of the first official attempts to answer the questions facing regional planners of the specialist medical services after the passing of the N.H.S. Act was the Ministry of Health booklet on *The Development of Consultant Services*, originally issued as a circular to Regional Hospital Boards. Most of the recommended scales of provision were in excess of those actually found in England and Wales, and they appear to have been, in the main, well-informed guesses by persons with practical experience in each of the branches of medicine dealt with. Some of these recommendations, however, now appear over-generous.

The table on p. 428 shows figures applicable to a particular hospital region (reduced to per 100,000 population) in respect of certain specialties. It should be noted that throughout this report the word "specialty" is used in the sense currently adopted by the Ministry of Health, accommodation and patients being classified under the specialty in which the consultant responsible holds his appointment. Thus, tonsil cases under the care of a general surgeon are counted in general surgery and not in ear, nose and throat surgery. Chronic Sick is an exception to this rule.

4. Health service planners now appear to ignore the 1948 recommendations and to rely largely on medical practitioners to draw attention to local needs inadequately met. Often it is only after their attention has been so drawn that regional or national statistics are studied, as a means of getting local contentions into perspective.

5. In the hospital service with which this report is particularly concerned it is normally assumed that all emergency cases secure admission within 36 hours at most, during which period a number of hospitals may, of course, have been unsuccessfully approached. It is realized, however, that in certain places there are short periods when this may not be achieved in certain cases. Unsatisfied demand is measured by waiting list statistics, e.g. average delay in admission of waiting list cases in each specialty. Average delay in securing out-patient appointments is also studied in some areas.

6. Waiting lists do not necessarily reveal all unsatisfied demand, however. Where there is a slow-moving list general practitioners may refrain from referring patients unlikely to receive treatment within a reasonable time. Where appropriate special facilities are non-existent there will

* The convenor of the group was B. B. Bonner, B.Sc.(Econ.), Statistical Officer, North East Metropolitan Regional Hospital Board, and the following other members of the group were present at more than three meetings: J. H. F. Brotherston, D.Ph., M.D., D.P.H., Reader in Public Health, London School of Hygiene and Tropical Medicine Ann Cartwright, B.Sc.(Lond.), Department of Public Health, London School of Hygiene and Tropical Medicine. H. W. G. Deeks, M.Sc.(Econ.), Statistician, Ministry of Works. D. M. Iles, A.M.R., Medical Records Officer, University College Hospital, London.

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Specialty	1 *Present Beds*	2 *Waiting List*	3 *Average Stay*	4 *Further Beds Required to Reduce List to nil in One Year*	5 *Number of Beds Recommended in Ministry Booklet*	6 *Officially Recommended Increase = 5–1*	7 6–4
General medicine	126 (*a*)	13	26	1	208		
Chronic sick	145	24	162	11	125	78	+66
Paediatrics	26	0	18	0	42		
	297			12	375		—
Ophthalmology	8	25	14	1	17	9	+ 8
General surgery	123 (*b*)	200	15	9	150		
Traumatic and orthopaedic	20	44	28	3	66	101	+81
Ear, nose and throat	14	508	5	8	42		
	157			20	258	—	—
Gynaecology	26	76	12	3	30	4	+ 1
Obstetrics	53	—	12	0 (*d*)	100	47	+47

Notes to Table

(*a*) The 126 beds include general practice medical beds.

(*b*) The 123 beds include dentistry and genito-urinary beds.

(*d*) In the case of obstetrics, the number of beds available in the region is sufficient for 60 per cent. of expected confinements, even allowing 20 per cent. of the beds for ante-natal treatment.

Col. 1 shows the existing scale of bed provision for the North-East Metropolitan Hospital Region, expressed as staffed available beds per 100,000 population.

Col. 2 indicates the number of patients awaiting admission to the Board's hospitals at December 31st, 1953, expressed per 100,000 population.

Col. 3 indicated the approximate average duration of stay in days of patients in the departments concerned.

Col. 4 assumes that the average stay of those now on the waiting list will not be dissimilar from that of all cases recently admitted, also that the existing number of beds is sufficient to keep the lists static, apart from seasonal fluctuations. This is broadly the case in the Region concerned. The choice of one year as the period for reduction to nil is in harmony with a measure of demand calculation recently made by Ministry of Health staff, the number of patients admitted during a year plus the number awaiting admission at the end of the year being taken as an estimate of the demand to be faced in the following year.

Col. 5 where, say, 150 beds was recommended for a population of 100–120,000, the larger population has been taken, thus giving 125 beds per 100,000 in this example.

naturally be no waiting list at all, though the latent demand for the non-existent service may be considerable.

7. Planners require assessments of need both to choose between competing claims for expenditure and to decide the scale of provision desirable in newly developed areas.

8. Assessments naturally involve estimation of the population served. Under the National Health Service this is not altogether a straightforward matter as general practitioners are free to refer their patients to hospitals and clinics at a distance from the area of residence. Teaching hospitals in particular tend to draw patients from a wide area and any hospital equipped with unusual facilities will serve a greater catchment population in respect of its exceptional department(s) than its common departments.

Existing services must be reckoned against population actually served, this being dependent on the relative capacity of facilities on the spot and those in neighbouring districts.

For planning purposes, however, estimates must be made of the population likely to use services at given sites if and when made available, and such estimates are normally based on geographical proximity and transport facilities.

In one or two hospital regions, an impression of the actual catchment populations of existing hospitals was gained by taking a census of the patients in hospital at a given moment and analysing

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them by food office area code. With the disappearance of ration books, surveys of patients in hospital by area of residence will become somewhat more laborious. It is important that such surveys be carried out over large areas, as the mere presence of patients from district X in hospital A must not be taken to imply that the catchment population of hospital A includes the whole of the inhabitants of district X. Patients from the same district may also be found in hospitals B, C and D.

It should be noted that the population served by existing services may easily be as little as half or as much as double the appropriate catchment population of the same hospital management committee assessed for planning purposes.

9. Assessments made by relating existing services and expressed demand to a population served suffer from the disadvantage that the degree of need being met may remain to some extent obscure. In addition to the point made in para. 6 overprovision may not be immediately apparent. Where services are lavish, they may still appear to be fully used, doctors being encouraged to keep patients under treatment or surveillance longer than is strictly necessary.

10. In estimating the need for hospital in-patient treatment, it is desirable to take into account the fact that there are groups of diagnoses in which the patient's home circumstances affect the urgency with which he should be admitted. Thus an infectious patient may be more likely to require admission if coming from an overcrowded household, and a non-infectious patient may be more likely to require institutional treatment if there is no one at home capable of nursing him.

11. Common symbols have been used to indicate factors common to several of the methods of assessment outlined in the following paragraphs. The form put forward in para. 12 may be regarded as idealized, being an exhaustive presentation of the causal factors in the demand for clinical services without regard to practical difficulties.

The form outlined in para. 16 is a first step towards recognition of practical considerations, but retaining the limits of demand and showing the elements to these limits. Para. 18 introduces a further broadening of the demand categories but further contracting of the causal elements. In para. 25 the elements of the causal situation are virtually obliterated, with only a crude estimate of need.

Assessing Need Independently of Existing Services

12. A form of assessment that was not based on facilities already available would inevitably depend mainly on field research work, and the results for each diagnostic group might be tabulated after the following manner:

Medical (Diagnosis) Demand	*Sociological Aspects*			
	Bad	*Doubtful*	*Good*	*Total*
Immediate . .	1	2	3	*d*
Non-urgent . .	4	5	6	*e*
No Demand . .	7	8	9	*f*
Total . .	*a*	*b*	*c*	Population Exposed

13. In Britain, the values of *d* and *e* would have to be obtained by inquiry amongst general practitioners to assess the numbers of patients they would have sent to hospital for specified groups of diagnoses if adequate hospital facilities were locally available. It would be helpful if separate tables could be drawn up for the three main age groups of the population, also for urban as opposed to rural areas.

14. The values of *a*, *b* and *c* might also involve field work, but for particular diagnostic groups and where the exposed population was the sum of the residents in a defined area, consideration might be given to the possibility of interpreting certain National Census statistics indicating numbers of persons per household, degree of crowding, etc.

15. For groups of diagnoses in which risk is likely to vary with sociological factors, the inquiry would have to be detailed enough to enable each cell in the range 1, 2, 3, 4, 5, 6 to be completed

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separately. Where risk of the particular illness is unlikely to vary with social factors, however, it may be possible to infer the values of the cells in the table on the assumption that

$$\frac{d \times a}{p} = \text{value of cell 1}; \quad \frac{d \times b}{p} = \text{value of cell 2};$$

and so on, p being the population exposed.

16. The difficulty of contingent probabilities might be overcome if general practitioners were asked to express their own opinion as to which of their patients fell into categories 1 to 3, 4, 5 or 6 over a period. 7, 8 and 9 would normally be the remainder of the practice population.

Where such field work was used to obtain directly a year's statistics of new cases (by diagnostic group) in a practice population of given size, there would—in Britain—be no need to distinguish between 1, 2 and 3, as the hospital service would undoubtedly be expected to treat all three of these categories. The table could therefore be simplified to:

New cases of.....(diagnostic group)
arising per 1,000 practice population in the year.....

Needing immediate admission	*d*
Admission medically desirable, socially urgent . .	*e*4
,, ,, ,, ,, desirable . .	*e*5
,, ,, ,, ,, unimportant .	*e*6

"Needing immediate admission" is, inevitably, a relative term. In some circumstances it may mean that early death can only be averted by prompt admission; in others it may mean that any delay in admission is likely to result in the illness or injury becoming considerably more painful or severe, or that a far longer time will be taken for recovery. Hence, in under-developed countries, where the hospital services may not even be adequate to cope with all the *d* cases, the inquiry classification would sub-divide *d* into *d*(*i*) admission vital, and *d*(*ii*) admission urgent but not vital; and in these circumstances *e* could be treated as a single category.

17. The figures in the above tables could be converted into their implied bed-day requirements by multiplying the annual number of new cases to be expected by the average stay in days of similar cases admitted in the recent past, allowing for the inevitable time-lag between the discharge of one patient and the admission of the next. A time-lag of one day was allowed for in estimating the beds required to clear the waiting list over a year in the table at para. 3 (col. 4). The time-lag is likely to be relatively short where non-urgent cases can be fed into the hospital from a waiting list, and somewhat longer for emergency conditions of which the incidence is variable and largely unpredictable, or at least, not accurately predictable (i.e. producing an irregular flow of patients for admission).

The average stay figures required could be obtained by analysis of cards punched from General Register Office hospital in-patient inquiry returns of patients discharged from representative groups of hospitals. Here, again, it would be helpful to differentiate between the three main age groups of the population.

18. For groups of diagnoses in which social factors are relatively insignificant from the point of view of urgency of admission (not to be confused with the point made in para. 15 which dealt with relative risk) and perhaps only half-consciously separated in the mind of the general practitioner, the classification could be simplified to:

Requiring immediate admission . .	*d*
Admission very desirable . . .	*e* (i)
Admission helpful	*e* (ii)

This form of table would also be appropriate where it is considered expedient to assess need for hospital beds without regard to diagnoses.

19. The field work for such absolute assessments of hospital bed requirements should be carried out over a single year, and the analysis preferably within six months thereafter, as delay in drawing conclusions reduces their value in that conditions may change before the resulting decisions are translated into effective action.

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20. In *Les Problèmes de L'Organisation Hospitalière aux Etats-Unis* (Paris 1950), Dr. R. F. Bridgman claimed that the mortality rate faithfully reflects the demand for hospital beds in a given community, and suggested that assessments of total bed requirements could therefore be adjusted in accordance with the crude deathrate (i.e. thus allowing for non-standard age-distribution in the population). This proposition, however, appears to rest only on the actual uptake of existing hospital beds in New York over a number of years, related to the actual deaths in the town.

Consideration of Existing Sources

21. The Fourth Report of the Ministry of National Insurance, for the year 1952, contained two new tables analysing spells of certified incapacity by reason of sickness terminated in 1950, using the World Health Organization's social security list of 50 causes and giving separate figures for males and females. The first table gave median durations, while the second table omitted these but gave a sub-division of the 50 causes into 140 categories. Further tables of this kind have since been produced in a Digest of Statistics Analysing Certificates of Incapacity for 1951 and 1952.

The use of this information is limited by the fact that it relates only to the insured portion of the working population, and doctors do not always enter a specific diagnosis on the certificate. Many illnesses of short duration are not reported to the Ministry, but these would be unlikely to have a significant effect on the demand for hospital in-patient accommodation.

22. The Survey of Sickness carried out by the Ministry of Health (1944–1951) produced some relevant information, e.g. distribution of persons interviewed according to number of days in hospital reported in a month, divided into three age groups and also into males and females. But the survey, which ceased at the beginning of 1952, had never covered persons under 16 years of age.

23. Hospital Service statistics for 1953, submitted to the Ministry of Health in respect of every N.H.S. hospital in England and Wales, showed for the first time a full breakdown by specialties of the average daily bed occupation and of the average duration of stay in days.

Since the beginning of 1955 (i.e. after the original production of this report) N.H.S. hospitals have begun to accumulate the data for a breakdown by specialties of the average daily number of staffed available beds "irrespective of actual use"—that is, with borrowed beds counting under the lending and not the borrowing department. The resulting averages for 1955 will probably be published early in 1957. However, current policy encourages elasticity of bed allocations as between consultants, and pooling of beds in the smaller hospitals, so that the proportions of empty staffed available beds in different departments, as calculated from official statistics for 1955, will have to be interpreted with caution. At all events, it may be possible to compute national averages for broad groups of departments against which the returns for particular areas may usefully be compared.

If in a large and self-contained area all the waiting lists are found to be negligible in relation to bed capacity and annual discharges, that area would appear to be adequately provided with beds for its population. But if, in addition, the average stays are unusually lengthy or the proportion of unoccupied staffed available beds is unusually high it would appear that the area may be extravagantly served, at least by comparison with the rest of the country.

24. The General Register Office analysis of eight general practitioners' records by Dr. W. P. D. Logan (H.M.S.O., 1953) included statistics of interest because they are given in diagnostic groupings. Their application was, however, limited by the fact that the choice lay between: (i) a selection of diagnoses together amounting to little more than half the patients referred to hospital out-patient departments by general practitioners, or (ii) a distribution of all cases into 18 groups of diagnoses in which no distinction was made between in-patient, out-patient and other referrals.

25. During 1955 the Hospital In-patient Morbidity Enquiry conducted by the General Register Office is being extended to cover a 1 in 10 sample of patients admitted to all hospitals (except mental hospitals) in a number of complete Regional Board areas. This is a marked improvement on the unrepresentative pilot inquiries so far analysed in G.R.O. publications. The returns will provide information on both diagnostic *and* specialty groupings, together with sex/age split and

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division into urban and rural areas; thus providing a basis for comparison and for estimation of the requirements of newly developed areas.

26. Diagnostic groupings are more tractable than specialty groupings, as the range of cases handled by particular types of specialist varies according to policy and population density. Thus, statistics broken down by diagnostic groups may be combined into specialty groupings somewhat differently when urban or rural districts are under consideration.

Routine statistics of the hospital service are almost entirely divided into specialty categories, but the surveys of hospital-treated sickness carried out under the auspices of the Nuffield Provincial Hospitals Trust in Ayrshire and Stirlingshire form a useful body of statistics of the uptake of hospital accommodation in a known population, by diagnosis, age, social class, etc. This information can be used for comparative purposes, but the standards cannot be taken as absolute unless subsequent investigations suggest that these areas are neither under- nor over-provided for in respect of hospital facilities. Apart from the Scottish studies, and until the results of the newly expanded G.R.O. Hospital In-patient Morbidity Inquiry are published (presumably in 1958), the study of eight general practitioners' records will remain the only other body of British statistics which can be related to a population comprising all age-groups *and* providing diagnostic groupings.

Use of Comparative Statistics instead of "Absolute" Assessments

27. Statistics from the eight general practices mentioned in para. 24 might be used to assess the consumption of hospital services by the practice populations and the results compared with the uptake of hospital facilities in other districts. The practices concerned were in different types of area and included the rather unusual practice of a woman doctor. Hence, not unnaturally, there was a wide variation in referral rates between the practices. However, this does not necessarily preclude the use of statistics relating to the combined practices.

28. Failing rapid surveys and estimation of absolute requirements, as suggested in para. 19, comparison with existing services in other areas may prove as helpful to planners as the application of rigid standards which might be obsolete (e.g. owing to changing therapeutics) by the time the planned specialist services have come to fit them.

29. Where the comparison suggested in para. 23 indicates that services in a given area may be on an unjustifiably luxurious scale (in relation to other parts of the country), it may be helpful to survey patients actually receiving the service there, classifying them according to degree of need for continued service, e.g. vital, important, helpful, needless; this being an adaptation of the kind of survey carried out by the Liverpool Regional Hospital Board when estimating the numbers of potential "Recovery Home" patients.

The hospital treated illness surveys carried out since 1951 in the Perth-Kinross area and in the Northern Regional Hospital Board area of Scotland form a useful addition to the class of statistics already produced in Scotland by the Nuffield Trust, and subject to the minor limitations referred to in para. 26 above.

30. Finally, it is, of course, recognized that in the special cases of maternity confinements, cancer, mental illness, mental deficiency and tuberculosis, other statistics are available from which the need for specialist facilities may be calculable, but it has not been considered appropriate to over-burden this report by dealing separately with each of these special categories.

Some Relevant Reading

BAILEY, N. T. J. (1954), "Queueing for medical Care", *Applied Statistics*, 3, 137–145.
BENJAMIN, B. (1954), "Medicine and Medical Services in the United Kingdom", *J.R. Statist. Soc. A*, 117, 210–232.
BRIDGMAN, R. F. (1950), *Les Problèmes de l'Organisation hospitalière aux Etats Unis.*
FRASER, A. M., & MCKINLAY, P. L. (1954), "A Preliminary Note on Hospital-treated Illness in the Northern Regional Hospital Board Area of Scotland." *Health Bulletin* XII No. 1. Edinburgh: Department of Health for Scotland.
General Register Office (1953), *Registrar General's Statistical Review of England and Wales for 1949.* Supplement on General Morbidity, Cancer and Mental Health. London: H.M.S.O.
—— (1954), *Registrar General's Statistical Review*, 1949. Supplement on Hospital Morbidity Statistics. London: H.M.S.O.
—— (1955), *Registrar General's Statistical Review*, 1950–51. Supplement on Hospital In-Patient Statistics. London: H.M.S.O.

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Health, Ministry of, (1945), *Hospital Survey Reports*. 10 vols. London : H.M.S.O.
—— (1950), *Development of Consultant Services*. London: H.M.S.O.
—— (1953), *Report for the Year* 1952, Part II. London: H.M.S.O.
—— (1954), *Report for the Year* 1953, Part I. London: H.M.S.O.
Hospital and Specialist Services Statistics for England and Wales, 1953. (1955) London : H.M.S.O.
LOGAN, W. P. D. (1953), *General Practitioners' Records*. Stud. Med. Pop. Subj., 7. London: H.M.S.O.
MACKAY, D. (1951), *Hospital Morbidity Statistics*. Stud. Med. Pop. Subj., 4. London: H.M.S.O.
MACKIE, W. (1954), *Perth General Hospitals: A Survey of Hospital Treated Sickness in* 1952. [Duplicated].
National Insurance, Ministry of, (1953), *Fourth Report . . .* 1952. London: H.M.S.O.
NORRIS, V. (1952), "A Method of estimating Hospital Catchment Populations", *Brit. Med. J.*, 129–133.
Nuffield Provincial Hospitals Trust, (1948), *Hospital and Community I* (*Stirlingshire*).
—— (1950), *Hospital and Community II* (Ayrshire).
Pensions and National Insurance, Ministry of, (1954), *Digest of Statistics Analysing Certificates of Incapacity*. [Duplicated.]
President's Commission on the Health Needs of the Nation, Report (1952), *Building America's Health*. Washington: U.S. Govt. Printing Office.
WILKINS, L. T. (1949), *Survey of the Prevalence of Deafness in the Population of England and Wales*. London: Central Office of Information.

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The Sources and Nature of Statistical Information in Special Fields of Statistics

National Income and Related Statistics

By J. E. G. Utting

Contents

		PAGE
I.	Introduction	434
II.	Definitions	436
III.	Social Accounts	439
IV.	Input-Output Statements	441
V.	The National Income White Papers and Blue Books	442
VI.	Comparisons over Time	446
VII.	International Comparisons	448
VIII.	Other Recent Estimates	448
IX.	Bibliographies	449
X.	References	449

Introduction

Until recent years practically all national income estimates have been the work of private individuals; official estimates are mainly the product of the war and post-war years. In Britain the work which is usually considered the first real attempt to apply modern concepts to the estimation of national income is *Natural and Political Observations and Conclusions upon the State and Condition of England*, written by Gregory King (1696), although Sir William Petty (1690) had partially explored the field in his *Political Arithmetick*. Parts of King's work were quoted by Charles Davenant (1699) in his *Essay upon the Probable Methods of making a People Gainers in the Ballance of Trade*, but it was not printed as a whole until 1802. King's estimates were derived from a calculation of the total population of England, which he put at some 5½ millions; these he allocated to social classes (*e.g.* temporall lords, knights, esquires, persons in offices, artizans and handycrafts, labouring people and outservants, etc.) in a scheme showing the number of families in each class, the number of persons per family (household), and the yearly income per family. He thus arrived at a figure of £43½ million as the "yearly income of the nation" in 1688. He also estimated the annual expenditure per head in each of his social classes and, by subtracting total expenditure from total income, calculated that the "yearly increase of wealth" was £1,800,000. A particularly interesting feature of these estimates was the fact that King's main objects were to consider the country's capacity for continuing the war against France—an object immediately comparable with that which gave such an impetus to national income studies during the last war—and to compare the economic strength of Britain, France and Holland, Britain's ally in that war.

Another notable early estimate is that of Colquhoun (1815) which set out to calculate the output and income not only of the United Kingdom but of the whole of the British Empire. Many of the estimates relating to the colonies were very sketchy, but Colquhoun printed detailed tables of the output of the various branches of productive activity in the United Kingdom and of the distribution of the incomes arising from this activity "among the various classes of society".

A further well-known British estimate is that of R. Dudley Baxter (1868) which was given in a paper read before the Statistical Society of London. Baxter used the 1861 Census figures to divide the population into two "income classes": the Upper and Middle Classes and the Manual Labour Class. He then proceeded to estimate the total of personal incomes (excluding poor relief, but including national debt interest) in each of his two classes. For the Upper and Middle Classes his estimates were based mainly on income tax assessments (with some allowance for the ever-present element of evasion); and for the Manual Labour Class the estimates were based on a subdivision by type of employment and the allocation of average earnings figures to each class of work. Separate

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calculations were made for England and Wales, Scotland, and Ireland, and yielded a total of personal incomes of just over £814 million for the year 1867. Of this total, £489·5 million was ascribed to the Upper and Middle Classes and £324·6 million to the Manual Labour Class. Baxter also subdivided his total of incomes between the Productive Classes ("derived from agriculture, mining, manufactures, or wholesale trade, and colonial and foreign property and loans"), the Auxiliary Classes ("derived from houses, conveyance and the retail trade") which are sometimes directly productive and sometimes not, and the Non-Productive Classes ("from the public service, professions and domestic employments; and also from fundholders in the Stocks of Great Britain") which he thought of as not wholly unproductive but only indirectly contributing to the "original income fund of the nation".

Later came the works on national income and its various components by Bowley and Stamp. These not only made estimates for the periods in which they were written, but also carried the figures back to much earlier dates. Thus Stamp (1916) gave adjusted figures for income-tax assessments back to 1842 and Bowley (1937) has annual estimates of total wages from 1860. Bowley also made estimates for intermediate incomes back to 1880, and both Bowley and Stamp gave figures for tax evasion. These various components have been used by Colin Clark (1951) to make estimates of the real national income, in periods varying in length from seven to ten years, from 1860 to 1913, and by A. R. Prest (1948) to provide annual estimates of national income from 1870.

In their book *The National Income*,1924, Bowley and Stamp (1927) made a comparative study of the national income in that year and in 1911. This work, like most of the other estimates mentioned, was based on the addition together of incomes of various kinds (*i.e.*, wages, taxable incomes, intermediate incomes, an allowance for evasion, etc.) as were the estimates for each of the years 1924–33 given by Colin Clark (1936) in his *National Income and Outlay*. Clark's figure for 1924 differed from that given by Bowley and Stamp, adjusted for a difference of definition, by about 5 per cent.

Tribute has been paid to Bowley, Stamp, and particularly Clark, in an essay by Richard Stone (1951*b*), for the way in which they raised the subject of national income statistics to the point where it was ready to develop into the official studies which helped to determine the allocation of our resources during the 1939–45 war and which have made a major contribution to our knowledge of the nation's economic situation in the years since. Stone has described in some detail the steps which led to the publication in April 1941 of the first of the National Income White Papers, entitled *An Analysis of the Sources of War Finance and an Estimate of the National Income and Expenditure in* 1938 *and* 1940. This, as its name implies, was more than just an estimate of the national income; it attempted to set together estimates of national income and expenditure and various related totals in a way which would show their interrelationships and be a guide to economic policy. Since that time there has been an annual National Income White Paper or Blue Book, developing from 16 pages and 8 tables in 1941 to 88 pages and 49 tables in 1954. This development has taken two main forms. First there is a natural increase in the amount of detail given and the degree of breakdown of some of the principal aggregates. Second, and more important conceptually, is the provision of more fully integrated sets of figures in the form of a system of social accounts and of simple input-output tables. The social accounts, which were first given in 1947, take the form of a system of accounts for the transactions of three broad sectors of the British economy (persons, companies and public corporations, and government), showing their interactions one with another and also, in an account which completes the system, with the world outside. The input-output tables show transactions between ten different groups of industries and also the payments of these groups for the use of factors of production and their sales to final buyers.

It should however be stressed at the outset that, unlike most kinds of official statistics, the official national income figures are admittedly *estimates*. They are compiled in the Central Statistical Office mainly from information which is obtained by other government departments and agencies, and which is usually collected primarily for some purpose other than the compilation of national income estimates. Some existing collections of statistics have been modified, and some new collections made, to suit the needs of national income estimators, but it remains true that the national income figures are obtained largely by the adaptation and adjustment of material which has been obtained for some other purpose. It follows from this that the estimates are subject to errors which are not very readily assessable, but which may be corrected from time to time as new information becomes available. No official estimates of the reliability of the figures have yet been

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published, although it is known that some of them (e.g. personal saving) are rather insecurely based. The problem has been discussed in a recent paper by C. T. Saunders (1954).

Now that official estimates are available in such detail, the work of private investigators is chiefly concerned either with the provision of historical series for periods prior to 1938 or with interpretation and further refinement of the official figures. In the first category work is proceeding on the provision of estimates, broadly comparable in definition with the official ones, for the years 1920–38 and earlier periods; while the second category includes attempts to evaluate the various aggregates in *real* terms (as is required for inter-temporal and interspatial comparisons), estimates for smaller areas or shorter periods than the official ones, and estimates of particular components (e.g., personal savings or inter-industry relationships) in greater detail than appears in the Blue Books.

Definitions

There is no single, unique definition of national income which commands world-wide acceptance. Opinions vary about the merit of including or excluding particular items, but the definitions used by the official estimators of the United States, the United Kingdom and other Commonwealth countries, and most countries of Western Europe, are basically similar, though there may be differences on matters of detail.

Partly because national income provides a convenient and recognizably "just" measuring stick for calculating national contributions of money, materials or manpower to international agencies, these bodies have given a good deal of attention to the standardization of concepts and methods. The League of Nations, before its dissolution, set up a committee of experts whose report, entitled *Measurement of National Income and the Construction of Social Accounts* (1947), was subsequently published by the United Nations. That body has also published a number of volumes of national income estimates of member countries and now has a regular half-yearly series on the subject. A booklet entitled *A Standardised System of National Accounts* (1952) has been published by the Organisation for European Economic Cooperation for the use and guidance of its member countries, and a similar document—but with greater emphasis on concepts and methods appropriate for underdeveloped countries—has been issued by the United Nations (1953). Nevertheless there remain wide divergencies of practice, particularly between countries of Eastern and Western Europe; it has been suggested by Barna (1953*b*), Jackson (1955) and others that this is a reasonable and justifiable result of the different circumstances of different authors or countries and the different purposes for which their estimates are intended.

In Britain, theorists who have used the idea of national income or dividend have usually started from the concept of the output of goods and services becoming available to the nation—either for consumption or for adding to its wealth—during a given period. Thus Marshall (1947) said "the labour and capital of a country acting on its natural resources produce annually a certain *net* aggregate of commodities, material and immaterial, including services of all kinds. . . . This is the true net annual income or revenue of the country". The significance of the word *net* in this definition is that it provides for "the using up of raw and half-finished commodities and for the wearing out and depreciation of plant which is involved in production". It will be seen that the money value of the national income, so defined, is the sum of the payments (wages, salaries, profit, interest, and rent) to the factors of production in the period considered. The same concept of national income can also be looked at as a sum of consumption expenditure and saving (suitably defined), since the income received in any period is either spent or saved.

There are however a number of points of detail which require further consideration in this general definition. First of all, in adding together the goods and services which comprise the national income in any period it is usual in industrialized countries to include only those which are normally bought and sold for money. Thus the services which a person renders to himself or gratuitously to his family and friends are not usually included, nor are those which he obtains from the use of his own property. An exception to this general rule is made in the case of houses. Since these are frequently let for rent, the benefit which an owner-occupier derives from living in his own house is normally valued at an imputed rent. But, by contrast, nothing is included for a man's use of his own motor-car or other household durable goods—even though other individuals may on occasions hire such goods. It is usual too to include the value of farm produce consumed

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by a farmer's family (at farm prices) and allowance is sometimes made—but not in the official British figures—for food grown for their own consumption by other members of the population. Clearly, the inclusion or non-inclusion of items not entering into a monetary exchange market can greatly affect the measurement of national income in countries where relatively few goods enter such markets.

Another important class of definitional problems relates to gross asset formation (or capital formation) and depreciation allowances. It is in many ways desirable that gross asset formation should itself be made as *net* as possible and should include only the value of new additions and improvements to the stock of capital goods, before allowing for that element of "wearing out and depreciation of plant" which occurs in spite of the fact that normal repairs and maintenance are being carried out. But in practice, of course, it is very difficult to draw a hard and fast line between repairs and maintenance, which merely keep the existing stock in as efficient a condition as possible, and renewals, replacements and improvements, which actually add to the stock of capital. Recent changes in definition in the National Income White Papers and Blue Books have been in the direction of excluding elements of repair and maintenance which were previously counted in gross capital formation.

Net asset formation is in principal a less ambiguous concept. It is intended to represent the net additions to the stock of capital assets, and it therefore excludes any element of repair and maintenance which has been counted in gross asset formation and also any further depreciation which has occurred to the existing stock of assets. There are however very considerable problems in the definition and measurement of this element of depreciation. It involves the concept of maintaining capital intact which, in times of changing prices, is a very difficult one to apply. Accounting measures of depreciation are still based mainly on the concept of providing a fund sufficient to cover the *original cost* of the asset in the course of its effective life; but this may be very different from its replacement cost. Businesses are not, of course, ignorant of this fact and many of them do make transfers to reserve in times of rising prices, which are intended to bridge the gap between the formal allowances for depreciation and some estimate of future replacement cost. But such transfers are not usually formally described as depreciation allowances and would not, in any case, be allowable as deductions in calculating profits for income tax purposes. The official British estimates of depreciation were for a long time based on income tax allowances but, since these were used as instruments of economic policy rather than to measure the true depreciation in any year, they led to an extremely erratic and inconsistent series of estimates. For this reason, no attempt has been made to estimate depreciation in the main tables of the official publications from 1953 onwards. Estimates based on tax allowances are still given in subsidiary tables.

Redfern (1955) has prepared unofficial estimates of gross and net fixed capital formation for the years 1938 and 1948–53 which use an estimate of depreciation based on replacement cost. These estimates are more fully described in section VIII.

An allied problem is that of the valuation of stocks. Since the national income aggregate is intended to represent the money value of a *real* flow of goods and services, it ought not to take account of any element of nominal profit or loss which results merely from a revaluation of existing stocks. Recent national income papers have tried to cover this point by dividing the change in the value of inventories into two parts, one representing the value of real additions to inventories and the other representing the change in book value of inventories due to price fluctuations.

Another question which will frequently arise in the consideration of national income figures is whether the goods and services included have been valued at "market prices" or "factor cost". The definition which we have so far used of national income as a sum of payments to factors of production is sometimes referred to more fully as the net national income at factor cost. These payments include an allowance for profits but they do not include any allowance for indirect taxes or subsidies which also enter into the prices at which goods and services are actually exchanged. If the flow of goods and services is being considered from the expenditure point of view it is more natural to use the "market price" concept which includes indirect taxes and excludes subsidies.

Definitional difficulties also arise in the treatment of goods and services which are provided free of charge by government. These are normally valued for national income purposes at the cost of providing them. Whilst this is a reasonable treatment for most services which are provided directly to consumers, it is sometimes argued that those which are rendered to businesses should be regarded as intermediate services which are already taken acount of in the value of the final product

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of the business. One of the principal exponents of this point of view is Professor S. Kuznets and the argument is fully discussed in his paper "Government product and national income" (Kuznets, 1951). There are very considerable practical difficulties in the way of any attempt to exclude from the national income the value of those services which government renders direct to businesses. In a great many cases any particular service will benefit both businesses and private individuals at one and the same time, and it is not possible to say what is the value that each derives separately. In practice no such attempt is made in the official British estimates or in those of the U.S.A. or most other countries, and government services are all included at cost.

Further difficulties in relation to central and local government arise in deciding which departments shall be classified as trading departments and be classed with other forms of business enterprise, and which shall be regarded only as collective consumers whose principal function is the consumption of goods and services on behalf of the community as a whole. The problem is discussed in the O.E.E.C. and United Nations publications already referred to and the division at present used in the British estimates is discussed in detail in the 1953 Blue Book. This differs appreciably from the definition previously in use.

Military expenditure may be treated in different ways. In the National Income Blue Books it is assumed that for national income purposes all military expenditure, except on the building of married quarters and purchase of land, should be regarded as consumption expenditure rather than asset formation. This is clearly sensible in wartime, although it is not immediately obvious that it is the best procedure in time of peace, especially in the case of military equipment, such as motor-cars and other communications equipment, which has normal civilian uses.

It is also the accepted British procedure that houses are the only items of consumers' durable goods which should be regarded as a part of asset formation. All other purchases by households and individuals are treated as a part of consumption expenditure. It is of course as a corollary to this that no allowance is made in the national income for the benefits which a consumer derives from his ownership of durable goods other than houses.

A number of other special problems arise in any more detailed study of the components of national income. If, for instance, one wishes to analyse the national product according to the industries in which it originates, there are the usual difficulties of defining industries and allocating particular businesses or plants to them and also others arising from the rather indirect way in which some services are paid for. Typical of these is the difficulty of deciding what part of the national product is contributed by the banking system. Banks do not recoup themselves for the services which they render out of the charges which they make to their customers, but out of the interest which they earn by the wise investment of moneys deposited with them. Thus, if their gross product is valued only at the direct cost to consumers, the net product of the banking system often turns out to be negative. Two principal solutions to this difficulty have been suggested. Stone (1947) proposes that the interest earned by banks in excess of that which they pay out should be included in the selling price of their product—their customers being credited with an imputed item equal to this interest and also debited with the same amount as a payment for the banks' services. Where the customer is a business enterprise this imputed charge is debited as an operating expense, but the corresponding imputed income is not treated as an operating incoming, so the income generated in that business is reduced by an amount equal to the additional income attributed to the banking sector. The official Australian estimates regard the banking system as a provider of final services to the community as a whole, rather like government, and the net income arising in banking is defined as the total of wages and salaries paid. The official British estimates have not yet attempted any solution to this difficulty; they treat banking like other businesses, with bank charges as the only operating incomings and a negative operating surplus.

Finally, in this discussion of general definitional problems, reference must be made to the question of defining the "nation" to which national income refers. The actual territory concerned is normally determined by its political boundaries and ships are regarded as part of the territory in which they are registered. The national income is then defined as the income accruing to a country's *normal residents*, and this term is usually taken to include all armed forces, wherever they may be stationed, and permanent residents temporarily abroad. In the United Kingdom businesses are regarded as resident if controlled from the United Kingdom and therefore subject to its taxes. Central and local government are of course resident institutions of the country with which they are concerned; but international organizations are usually regarded as extra-territorial, though their

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staffs may be treated as residents. If one wishes to consider the product arising from activity which is actually and physically carried on within the territory of a given country, the concept which corresponds to national income is that of "net domestic (or geographical) product". This includes income payments to foreign workers temporarily employed in the territory and all rent and profit originating from activity in the territory even if paid to non-residents, but excludes all income of residents resulting from productive activity abroad. It has sometimes been called the "*domestic* national income", and can be measured at either market prices or factor cost.

The following tables, based on those in the *Standardised System of National Accounts* (1952), illustrate the relationship between geographical product and national income, and also between other income, expenditure and product concepts:

TABLE 1

National Income and Product

1. Gross domestic product at market prices (*i.e.*, the ouput of goods and services from production in domestic territory)	7. Income of residents from productive activity at home and abroad:
2. *less* Indirect taxes	(*a*) Remuneration of employees
3. Subsidies	(*b*) Income of independent traders, etc.
Gross domestic product at factor cost	(*c*) Rent, interest and dividends
4. *less* Depreciation	(*d*) Undistributed corporate income
Net domestic product at factor cost	(*e*) Government income from property and entrepreneurship
5. *less* Income payments to non-residents	(*f*) *less* Interest on government debt
6. Income received by residents from rest of world	
Net national product at factor cost	National income

TABLE 2

National Product and Expenditure

1. National income	5. Consumers' expenditure on goods and services
2. Depreciation	6. Government current expenditure on goods and services
3. Indirect taxes	7. Gross domestic asset formation:
4. *less* Subsidies	(*a*) Private fixed asset formation
	(*b*) Public fixed asset formation
	(*c*) Change in stocks
	8. Exports to and factor income payments from the rest of the world
	9. *less* Imports from and factor income payments to the rest of the world
Gross national product at market prices	Gross national expenditure at market prices

Social Accounts

The social (or national) accounting approach to the presentation of the various components of national income estimates is largely a post-war development. The object of a system of social accounts is to present in a summary form all the transactions taking place in a given economy, usually a national one, in a given period. Since every transaction which takes place is necessarily at one and the same time both a receipt and a payment, this summary can be presented in an accounting form in which every transaction appears on both sides of the system of accounts. Of

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course, for any particular national economy some of the transactions will be with entities outside the country under consideration, and this difficulty can be overcome by the inclusion of an account which shows the counterpart of all those transactions between the nation and the rest of the world. One of the objects of such a presentation is to show, in a more detailed way than do the more old-fashioned statements of national income and expenditure, the various interrelationships between different parts of the economy and the indirect effects of any particular act of economic policy. The advantages of the social accounting approach have been stated by Stone (1951*a*) in his paper "Functions and criteria of a system of accounting" and also in the publication *National Income Statistics*, 1938–1948, (1950) issued by the United Nations. These advantages may be summarized as follows:

(*a*) It is of great assistance in dealing with problems of consistency in definition.
(*b*) By emphasizing the interrelationships between different items it enables the most efficient use to be made of the available statistical information.
(*c*) It provides a logical framework for the collection of information.
(*d*) It is particularly useful in forecasting, since the interrelationships in the system necessarily impose certain restrictions on the freedom of variation of the different items. These restrictions are brought out by a system of social accounts in a way which might be overlooked if the items were being forecast independently.

The amount of detail to be incorporated in a system of social accounts and the particular form of summary of transactions which is employed must necessarily depend upon the purpose for which the accounts are drawn up. Nevertheless Stone has suggested one division which appears to be fundamental. This is the division of economic activity into three classes: production, consumption, and adding to wealth; these can be represented in a system of social accounts by three different forms of account: operating, appropriation, and capital (or resting). These correspond to what in commercial accounting terminology would probably be called, the trading account, a combination of profit and loss account and appropriation account, and capital reconciliation statement. Each of these three forms of account can in principle be drawn up for whatever different sectors the economy is divided into. These sectors will be broad groups of economic entities into which it is considered useful to divide the economy for the purposes for which the accounts are being drawn up.

In the National Income Blue Books, the table which summarizes the underlying system of social accounts shows the following three sectors:

(*a*) Persons (including non-profit bodies, and the business activities of professional persons, farmers and other sole traders and partnerships).
(*b*) Companies and public corporations.
(*c*) Public authorities.

The more detailed tables however provide all the elements of a comparable five-sector system by giving separate information for companies and for public corporations (broadly the nationalized industries) and by splitting public authorities into central and local government.

A rather more usual subdivision into three sectors would provide accounts for:

(*a*) Business enterprises (including all sole traders and partnerships in their business capacity).
(*b*) Households and individuals (usually including non-profit bodies).
(*c*) Public authorities.

This again might be divided into more sectors by splitting those mentioned into their component parts.

Since the U.K. tables show only a consolidated production (or operating) account for all three sectors, the difference between these two groupings is less marked than at first appears to be the case, except that substantial business transactions do appear in the capital account of persons in the British figures.

Within the accounts for each sector it is usual again to subdivide transactions into categories which appear significant from the point of view of the user of the accounts. Thus it will normally be the case that transactions which involve some real consideration (such as the purchase of goods and services) will be separated from transactions which only involve a financial consideration (such as loans or the purchase of securities), and that these in turn will be separated from transactions in which a money payment is made without any consideration being received in return (such as social

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security benefits). Further subdivision can be carried to whatever lengths seem desirable and possible. For instance, it is usual to distinguish wages and salaries from other forms of factor payments, to show direct and indirect taxes separately, and so on.

In practice severe limitations are placed upon the amount of detail which can at present be shown in social accounting systems by the amount of statistical information which is available. Thus, although the United Nations (1950) listed thirteen countries which published official social accounts, and some of these used more than the three sectors listed above, in none of them was the full three account system used for every sector. Instead, various kinds of consolidation were used, either over sectors within a particular kind of account or in some cases over accounts within a particular sector. Most countries use a combined capital account which is a consolidation of the capital accounts of all the sectors within the economy and it is also common to combine the operating and appropriation accounts for government and also for households and persons. Two typical forms of consolidation, those now used in the United Kingdom and in the United States, are shown in the diagrams which follow. It will be seen that in the United Kingdom version the consolidations are wholly over sectors within a particular type of account, whereas in the United States version there is both consolidation over sectors and also consolidation over accounts. The first official social accounts of the United Kingdom appeared in the National Income White Paper of 1948, but the present form with separate capital accounts has only been in use since the 1953 Blue Book.

Consolidations in the Official Social Accounts of the United Kingdom

Type of account / *Sector*	*Operating*	*Appropriation*	*Capital*	*External*
Persons . . .		———	———	
Companies and public corporations .		———	———	
Government . .		———	———	

Consolidations in the Official Social Accounts of the United States of America

Type of account / *Sector*	*Operating*	*Appropriation*	*Capital*	*External*
Enterprises . .	———			
Households . .	———			
Government .	———			

Input-Output Statements

Social accounts summarize the transactions taking place in an economy in such a way as to show the interdependence of a number of broad sectors and the principal kinds of transactions between them. Input-output tables are a different form of summary which concentrates mainly on a more detailed subdivision of the industrial sector and on those transactions which involve the exchange of real goods and services.

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The general form for such a table has been described by Leontief (1951) and elaborated in a number of later publications by the same author and others; and its relationship to a social accounting system has been discussed by Stone and Utting (1953) and Stone (1954*b*). The main body of an input-output table usually consists of a matrix showing, for each of a number of different "industries", its purchases of goods and services from each of the other industries and its sales to them. Purchases, or inputs, are usually shown in the columns and sales, or outputs, in the rows. This matrix need not necessarily be square since a more detailed subdivision of industry may be used in either the rows or columns. In any case, it is usual to complete the summary of transactions by adding further rows and columns showing wages and salaries, profit incomes, taxes, imports, etc., in the rows and final purchases by consumers, exports, capital formation, etc., in the columns.

Very detailed input-output tables have been constructed for the United States both by Leontief and by official sources. The only official tables so far available for the United Kingdom are those in the National Income Blue Books. The first appeared in the 1952 Blue Book and related to the year 1948; it used eight industrial subdivisions. The 1954 Blue Book gives an input-output table for 1950 which has ten industry groups.

In addition, Barna (1952 and 1953*a*) has prepared an input-output table for the United Kingdom in 1935, using figures from the Census of Production of that year, which gives a much more detailed classification of industry, and work is now proceeding on a very detailed table using the 1948 Census of Production.

The National Income White Papers and Blue Books

British national income estimators have nearly all adopted the income approach of the three main methods (income, expenditure and product) available for the construction of their estimates. This results partly from the early introduction of income tax, which provided figures—not necessarily very reliable—for at least the higher ranges of income. The same source of information may well be said to have been the backbone of the series of official estimates, which, however, also developed at an early stage figures built up from the expenditure side aided by information available from the wartime systems of rationing and control. Although output figures were used to some extent in the calculation of the expenditure estimates, the product approach has only recently been used to any appreciable extent. Material obtained from the Censuses of Production and Distribution is now used in building up the industry detail for income and the product detail for expenditure, and may well be further developed in the future.

From 1941 to 1951 the National Income White Papers were published in April of each year in conjunction with the Budget, and contained figures—increasingly detailed as time went on—relating to the preceding calendar year and to a certain number of other years (see Table 5). In 1952, Budget day was early and instead of the full national income tables appearing at that time a new White Paper called *Preliminary National Income and Expenditure Estimates*, 1948 *to* 1951, was introduced. The full tables were not published until August 1952 but then appeared in great detail in the form of a Blue Book. This procedure has been repeated in the two subsequent years, preliminary estimates appearing as a White Paper at the time of the Budget and a detailed Blue Book appearing in August. The preliminary estimates are presented in the form of summary tables relating to the overall economic activity of the United Kingdom and corresponding to the first seven tables of the 1954 Blue Book, described below.

The Blue Book published in 1954 relates to the years 1946–53 and is in ten main sections. These are:—

I. Summary Tables.
II. Output and Expenditure at Constant Prices.
III. Industrial Input and Output.
IV. Personal Income and Expenditure.
V. Companies.
VI. Public Corporations.
VII. Central Government including National Insurance Funds.
VIII. Local Authorities.
IX. Combined Public Authorities.
X. Gross Capital Formation.

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The summary tables in Section I present the principal statistics of the national income and expenditure and are based on a system of social accounts which is summarized in one of them (no. 7). The tables in the remaining sections of the Blue Book are all more detailed descriptions of components of the summary tables or other elaborations of them.

The first table shows how the gross national product is made up either as the sum of the expenditures which generate it (with adjustments for foreign trade, indirect taxes and subsidies) or as the sum of the factor incomes derived from its production (with adjustments for stock appreciation and net income from abroad). The table presents figures for each of the years 1946 to 1953. Those for 1953 are reproduced below.

TABLE 3

Gross National Product, 1953

(£ *million*)

Expenditure Generating Gross National Product At Market Prices		*Shares in the Gross National Product (factor incomes)*	
Consumers' expenditure	11,076	Income from employment	9,488
Public authorities' current expenditure on goods and services	3,074	Income from self-employment*	1,604
Gross domestic capital formation:		Gross trading profits of companies*	2,463
(*a*) Fixed capital formation	2,333	Gross trading surpluses of public corporations	302
(*b*) Value of physical increase in stocks and work-in-progress	201	Gross profits of other public enterprises*	66
		Rent*	553
Total domestic expenditure at market prices	16,684	Residual error	59
Exports and income received from abroad	3,853	Total domestic income before providing for depreciation and stock appreciation	14,535
less Imports and income paid abroad	−3,726	*less* Stock appreciation	75
less Taxes on expenditure	−2,370	Gross domestic product at factor cost	14,610
Subsidies	355	Net income from abroad	186
Gross national expenditure at factor cost (= gross national product)	14,796	National income and depreciation (= gross national product)	14,796

* Before providing for depreciation and stock appreciation.

The second table of this section gives further details of personal income and expenditure, while the next three present income and expenditure (not production) accounts for corporations, central government and local government respectively. The sixth is the combined capital account of the United Kingdom and shows how gross fixed capital formation, the physical increase in stocks and net foreign investment are financed from the saving of the different sectors and capital grants from abroad. The figures for 1953 were as shown in Table 4.

The seventh table summarizes the United Kingdom's transactions with the rest of the world. More detailed information on these transactions is available in the White Papers on the Balance of Payments; it is somewhat rearranged in the National Income Blue Book to accord with the concepts used in other parts of that publication.

The next table is the social accounts of the United Kingdom for 1953, and relates to that one year only. The accounts are not presented in the familiar accounting form but in a tabular statement with a separate double column for each of the eight accounts. The rows of the table are used for different kinds of transaction, and the two columns for each account show receipts and payments respectively. Thus in any one row (e.g. that for "saving excluding stock appreciation") the table shows all the payments from different accounts (in this case, income and expenditure accounts) and all the receipts into different accounts (in this case, capital accounts) in respect of that kind of transaction. Thus the receipts and payments in any one row will balance one another; similarly of course the two columns for any one account must both sum to the same total; and this form of presentation exhibits in a very clear fashion the articulation of the system as a whole.

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TABLE 4

Combined Capital Account, 1953
(£ *million*)

Receipts		*Payments*	
Saving, before providing for depreciation and stock appreciation:		Gross fixed capital formation at home	2,333
(*a*) Persons	870	Value of physical increase in stocks and work-in-progress	201
(*b*) Companies	1,207	Investment abroad (net)	225
(*c*) Public corporations	163		
(*d*) Central Government			
(i) Surplus on revenue account	218		
(ii) *less* Taxes on capital	−166		
(iii) Transfers to capital accounts	121		
(*e*) Local authorities	118		
Additions to interest and dividend reserves	55		
Additions to tax reserves	−7		
Total national saving, before providing for depreciation and stock appreciation	2,579		
less Stock appreciation	75		
Capital transfers from abroad			
(*a*) Capital grants from overseas governments (net)	—		
(*b*) Other Government receipts	46		
Residual error	59		
Total	2,759	Total investment	2,759

The ninth of these summary tables shows the factor shares in the gross national product, both before and after income taxes, in rather more detail than in the first, so as to show their distribution between persons, public authorities and the undistributed income of corporate businesses. Table 10(i) is a further presentation of the gross national product, for the years 1948 onwards only, using the product approach and showing the contributions of fourteen different branches of economic activity to the national total; while Table 10(ii)—the last in this section—is a slightly different formulation of the expenditure side of Table 1, showing exports, imports, and net income from abroad as three distinct items.

Section II of the Blue Book revalues the gross domestic product for each of the years 1946 to 1953 at 1948 prices. It contains two tables, the first of which uses an expenditure approach and revalues at both market prices and factor cost. The second uses a product approach and presents *index numbers* of the product arising in eleven branches of activity at 1948 factor cost.

Section III is concerned with industrial input and output. The first table is a more detailed presentation of the gross domestic product by industry of origin, already shown in the summary section; this time the product arising in the different branches of activity is further subdivided by the types of income to which it gives rise. Next comes a further analysis of the wages and salaries paid by the manufacturing industries, which are shown as a single branch in the preceding table; they are here subdivided into 14 groups, and wages and salaries are shown separately for each. Then follows the input-output table for 1950, which has already been described; and the final table of the section presents a simple production account for manufacturing industry for the years 1950–53, showing the supplies available from home production and imports, and their use for consumption, capital formation, exports, etc.

Section IV deals with personal income and expenditure. It has seven tables, mainly concerned with an analysis of consumers' expenditure. The first two are, however, concerned with income; one showing total personal income and the taxes met out of it for the years 1946 to 1953, and the other showing the distribution of personal incomes by ranges of income before tax in 1938, 1949 and 1953. The main tables on consumers' expenditure are repeated at current market prices and at 1948 market prices and give a very detailed commodity breakdown of total expenditure; the figures include the expenditure of non-profit bodies as well as of persons in the usual sense. The price indices used, or implied, in the revaluation at 1948 prices are given in a separate table. The section

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also includes a less detailed commodity breakdown of consumers' expenditure at current factor cost and, in less detail still, at 1948 factor cost.

Section V relates to companies. The first of its tables is a slightly more detailed statement of the contribution of companies to the corporate income account included in the summary. The other table in this section gives an industrial analysis of company trading profits showing gross profits, including depreciation, and the income tax depreciation allowances, for the years 1947 to 1952. The depreciation allowances include the "initial allowances" which were sharply varied during this period, and so have very little economic significance.

Section VI presents operating, appropriation and capital accounts for the combined public corporations, for the years 1946–53. It also analyses the appropriation and capital accounts by the industries in which these corporations operate, distinguishing six groups, for 1948–52.

Section VII has two tables, a revenue account and a capital account, for the transactions of the central government (including national insurance funds) and a separate revenue account for the national insurance funds alone. An important feature of these tables, and of those in the two following sections, is that they relate to the activities of public authorities as "collective consumers". No details are given of the trading activities of these authorities apart from an item on the income side representing gross trading profits, and expenditure on goods and services by non-trading departments is shown net of the receipts for any goods or services which are re-sold to other consumers. The income side of the revenue account of central government gives a fairly detailed analysis of tax revenue, while the expenditure side is concerned mainly with broad categories—expenditure on goods and services, subsidies, national insurance benefits, etc.—several of which are further broken down in subsequent tables. There is a very rudimentary purpose classification of central government expenditure on goods and services, distinguishing military defence, health services, and other expenditure.

The central government capital account which relates to both trading and non-trading bodies is divided into two parts. The first shows the funds available for capital purposes, from current surplus or from abroad, and the way they were used to finance capital formation, stock changes and capital payments abroad. The balancing item here represents net lending or borrowing, and the second part of the account gives further details of the lending and borrowing items which contributed to this net result.

The revenue account of national insurance funds gives further details of the contributions and expenditure on benefits, which are already included in the central government account.

Section VIII provides revenue and capital accounts for local authorities. They are similar to those for the central government, but give fairly detailed purpose classifications of both grants from the central government and net expenditure on goods and services.

Section IX gives, for central and local government combined a series of detailed analyses of items which have already appeared in the two preceding sections. The first four tables are all purpose classifications, in quite considerable detail, of current expenditure on goods and services, gross fixed capital formation, subsidies and current grants to persons (including, of course, non-profit bodies and institutions), respectively. The remaining tables of the section relate to taxes. The first gives an allocation of income taxes by type of income, and of capital taxes by the type of holding on which they are levied; the second gives a sector allocation of income taxes; and the third allocates taxes on expenditure *less* subsidies by the type of expenditure (consumers', public authorities', capital formation and exports) on which they fall.

The tenth, and last, section of the Blue Book gives details of gross capital formation. The first is a sector analysis of the capital account in Section I. It shows, for each of the years 1948–53, the funds available to different sectors from their saving and from capital transfers from abroad, and the expenditure of these on real and financial assets. In this table tax and dividend reserves, etc., are shown as if they were a separate sector and drawings on them by other sectors appear as borrowing from the reserves sector.

The next five tables all analyse gross *fixed* capital formation in varying detail by type of asset. The first of them gives a sector breakdown of expenditure on four groups of assets—vehicles, ships and aircraft; plant and machinery; new housing; other buildings and works, land and legal fees, stamp duties, etc. The next two omit the sector breakdown but give more detail of vehicles, ships and aircraft, and show the legal fees, stamp duties, etc., as a separate item; one is for the years 1947–53 in current prices, and the other is for the same years in 1948 prices. The next table reduces

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the groups of assets to three by combining new housing with other buildings and works, but gives a very detailed analysis of expenditure by the industries and trades in which it occurred or, in the case of public authority expenditure, by purpose; and the next table gives an even more detailed industrial breakdown for manufacturing industry, but only for the years 1948–52.

The two remaining tables in the section both give figures of capital formation in stocks and work in progress. One gives a broad sector analysis of the total, and splits it between the value of the physical increase and the change due to revaluation of existing stocks. It was, however, emphasized in the 1953 Blue Book that this division is highly uncertain, and that situation presumably still applies. The other gives a more detailed industrial breakdown of the total increase in value without specifying its two component parts. This final table also includes the only national wealth estimates in the whole of the Blue Book, in a column showing the total value of stocks* held by each branch of industry at the end of 1952.

The 1954 Blue Book finishes with several pages of notes, but these relate primarily to changes since the previous Blue Book and do not provide a complete description of the many tables and items. The latest complete description and definition was given in the Blue Book published in 1952, and reference has to be made to that volume for information about many of the items in the later Blue Books. There have, however, been a number of revisions and amendments since then—particularly in 1953—and these are fully described in the years in which they first occur. The 1954 Blue Book gives a detailed description of the summary tables, but for other items it is usually desirable to refer to both the 1953 and 1952 volumes.

Although the items appearing in the tables are now fairly fully defined, rather little information has so far been available about the sources from which the figures are compiled or about the reliability of the estimates. However, the 1954 Blue Book promises that "a work is now in preparation describing in detail the methods of estimation and the sources from which the estimates are derived", and this will clearly be invaluable in the interpretation and use of the figures.

Comparisons over Time

The previous discussion will have indicated that the National Income Blue Books are even now still in the development stage and that successive issues differ from one another both in content and in the definitions which they use. Each issue contains figures on a comparable basis for a number of earlier years but the last White Paper to repeat the main series for all years back to 1938 was that issued in 1947 (giving figures for the calendar years 1938–1946 inclusive). The later White Papers up to 1951 included figures for 1938 in respect of most of the main totals but omitted a number of the intervening years. The series of Blue Books published since then have each taken 1946 as their earliest year, and the three sets of Preliminary Estimates all start from 1948. The years covered by the main tables in the White Papers and Blue Books published so far are as follows:

TABLE 5

National Income White Papers and Blue Books

White Paper		*Years Covered by Main Tables*														
Cmd. No.	*Year of Publication*	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953
6261	1941	—		—													
6347	1942	—		—	—												
6438	1943	—		—	—	—											
6520	1944	—	—	—	—	—	—										
6623	1945	—	—	—	—	—	—	—									
6784	1946	—	—	—	—	—	—	—	—								
7099	1947	—	—	—	—	—	—	—	—	—							
7371	1948	—						—	—	—	—						
7649	1949	—								—	—	—	—				
7933	1950	—								—	—	—	—	—			
8203	1951	—								—	—	—	—	—	—		
Blue Book	1952									—	—	—	—	—	—	—	
,,	1953									—	—	—	—	—	—	—	—
,,	1954									—	—	—	—	—	—	—	—

* It appears from the 1952 Blue Book that this column also includes work in progress.

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The Annual Abstracts of Statistics have continued to print 1938 figures in eight tables, corresponding to the first seven accounts in Section I and the operating account of public corporations in the National Income Blue Book, but these do not include figures for the years 1939–45. Changes in definition since 1947 have involved amendment of the 1938 figures, so it is clear that there is no strict comparability between the present series of figures going back to 1946 and the earlier series for the years 1939–45 inclusive. More recent figures for the years 1939–45 have been given in the *Statistical Digest of the War* (1951) but these are based on the methods and concepts used in the 1951 White Paper. Changes since that time have particularly affected the estimates of capital formation, but a good deal of the income and expenditure information is comparable with later estimates.

Apart from changes in definition, it is emphasized by the authors of the Blue Book that the figures for the latest year, although they are now published with less urgency than the White Papers, are necessarily provisional and subject to revision when further information is available. Some interesting tables showing the effects of these revisions, and of changes in definition, on the figures given for certain items in a number of successive White Papers have been published by J. Mars (1952).

If one goes back to some of the earlier estimates of national income published before the war one encounters similar difficulties due to differences in definition. Individual writers have frequently tried to correct for these in comparing their estimates either with their own earlier writings or with figures published by other writers covering approximately the same years. Some roughly comparable figures of national income for each of the years 1870–1946, based on the work of Bowley, A. J. Brown and Stone, have been given by Prest (1948). The author has emphasized that these estimates were prepared for the purposes of market demand analysis and great precision is not claimed for them. The main estimates are based on current prices, but the tables also include a figure for the national income at constant (1900) prices for each of the years up to 1938.

Time series for a number of related totals—but not as yet for the aggregate national income—are being provided in the series of *Studies in the National Income and Expenditure of the United Kingdom* sponsored jointly by the National Institute of Economic & Social Research and the Department of Applied Economics at Cambridge. One object of this series is to provide detailed estimates for periods before 1938 which are not only consistent one with another but are also consistent with the official estimates for the years 1938 onwards. Volumes so far published give a very detailed analysis of consumers' expenditure on food, drink, tobacco, rents, fuel and light for the years 1920–1938 (Stone, 1954*a*), comparable estimates in less detail covering the whole of consumers' expenditure for the years 1900–1919 (Prest, 1954), and an industrial analysis of wage and salary payments for the period 1920–1938 (Chapman, 1953). Further volumes are promised on the remainder of consumers' expenditure, 1920–1938, and analysing the whole system of demand relationships during the first half of this century, and on the transactions of central and local government in the years 1920–1938.

The need to adjust for changing prices is of course a main obstacle to any comparisons of real national income over long periods of time. Reference has already been made to Section II of the 1954 Blue Book which relates to output and expenditure at constant prices. The two tables of this section attempt to revalue the gross domestic product of the United Kingdom in 1948 prices, the first using an expenditure approach and the second a product approach. These two methods are described in an introductory section of the 1953 Blue Book and the notes to the 1954 Blue Book and in a paper by Nicholson (1955). The problems of constructing an index number of real product have been described in detail by Carter *et al.* (1948) and by Reddaway (1951). Descriptions of the London and Cambridge Economic Service's index of the real product of the United Kingdom, which preceded and is basically the same as the official index, have been given by Reddaway (1950), Carter (1952) and Adams (1953). In addition to this annual index of the total national product which is published in the Blue Books, a monthly index covering only industrial production is now published in the *Monthly Digest of Statistics*. It is described in *The Index of Industrial Production* (1952).

Estimates in real terms reached from the expenditure side also have their difficulties but are less hazardous when restricted to consumers' expenditure. The Blue Books give a detailed commodity breakdown of annual consumers' expenditure in 1948 prices, and quarterly figures in less detail (13 commodity groups) are published in the *Monthly Digest*.

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International Comparisons

The problems of making international comparisons of national income are in principle the same as those of making inter-temporal comparisons. Such comparisons must essentially be made in real terms and cannot be obtained merely by converting money national income into a common currency at the ruling exchange rate, since relative prices will often be widely different in different countries. In any practical context there will usually also be differences in definition between the estimates for the countries concerned. Even if there are no differences of definition it may well be that for countries with widely differing industrial development the same definition may reflect essentially different things; this would clearly be the case if for instance the national income estimates omitted the value of crops grown by persons for their own use. The United Nations half-yearly publication *Statistics of National Income and Expenditure*, besides now giving information in varying detail about the official estimates for 74 different countries, attempts to adjust as many as possible of these on to a common conceptual basis, but does not tackle the price index problem. The Organisation for European Economic Cooperation has also set up its own standardized system of national accounts and hopes that the member countries will provide national income statements in conformity with this system, even if they also prepare statements which use other concepts and definitions. It has recently published a report entitled *Statistics of National Product and Expenditure*, 1938, 1947–52 (1954) which presents statistics for the member countries, the United States and Canada, based on a common set of definitions. Details of the sources and methods used provide a good illustration of the problems involved in adjusting to a common basis.

The simpler kinds of international comparison, based on exchange rates, were made by the United Nations in *National and Per Capita Incomes of Seventy Countries in* 1949 *Expressed in U.S. Dollars* (1950). A much more sophisticated comparison of the national products of the United Kingdom, United States, France, Germany, and Italy has recently been made by the Organisation for European Economic Cooperation (Gilbert & Kravis, 1954); this uses an expenditure approach to the total of national product. An industrial approach to international comparisons of real product, which has been discussed by Paige and Adler (1953), is also being developed.

Other Recent Estimates

Current official British estimates of national income and its components are still almost wholly limited to the United Kingdom as a whole and to annual figures. For certain purposes this is an undesirable limitation and it would be preferable to have quarterly or even monthly series of figures and to have estimates for smaller areas. The *Monthly Digest of Statistics*, besides its quarterly figures of consumers' expenditure and monthly index of industrial production, contains other series (on e.g. wage rates, prices and production) which give an indication of short term movements but are not explicitly related to national income estimates in the official publication. Seers (1949 etc.) and others have however used indicators of this kind in the construction of quarterly national income estimates during the period 1949–52 which were published, with comment, in the *Bulletin* of the Oxford Institute of Statistics.

Miss P. M. Deane, working at the Department of Applied Economics at Cambridge, has been engaged on the other problem, of providing estimates for smaller areas than the whole of the nation. She has been constructing a system of social accounts for the twelve administrative regions of the United Kingdom for the year 1948. A preliminary report on regional variations in incomes from employment has been published (Deane, 1953*a*); the main report is in preparation and will be published by Cambridge University Press.

Estimates of the Scottish national income for the years 1924–48 are given by A. D. Campbell (1954) in a chapter of *The Scottish Economy*, by members of the staff of Glasgow University. The estimates are expressed in absolute money terms and as real income per head, and are also broken down into various income components for selected years.

National income and social accounting estimates for Northern Ireland for the year 1952 have been made by C. F. Carter and Mary Robson (1954). These were presented and compared with figures for the United Kingdom and for the Republic of Ireland in a paper read to the Statistical and Social Inquiry Society of Ireland in 1954.

The Oxford Institute of Statistics has also been undertaking research which is aimed at improving the information available on personal saving—official estimates of which have always been described

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as highly uncertain. Their method has been one of direct enquiry of a sample of households, first in Oxford and later on a national scale. Various aspects of their results and methods have been described by Lydall (1953, 1954).

Another serious weakness in the official figures, which has already been referred to, arises in relation to the estimates—or, rather, the absence of estimates—of depreciation and net capital formation, and here too a private contribution has done much to close the gap. Redfern (1955), starting from the official estimates of *gross* fixed capital formation in 1938 and each of the years 1948–53, has derived estimates of *net* fixed capital formation of similar scope and classification, using depreciation allowances which are based on replacement cost. His work also includes estimates of the gross replacement value of domestic fixed capital at the end of each of the years 1938, 1947 and 1952 and corresponding estimates of the written down replacement values, allowing for accrued depreciation.

Bibliographies

Writings on national income and its components have been so numerous that it would be difficult to give even a select bibliography in a paper of this kind. There is however a useful, though somewhat imprecise, bibliography in *Studies in the National Income* 1924–1938 edited by Bowley (1944) for the National Institute of Economic and Social Research. This is a classified bibliography which covers books and journals published in quite a large number of countries.

The International Association for Research in Income and Wealth prepares a series of current quarterly bibliographies which are both classified and annotated. They are based on reports received from national income scholars in some 35 different countries and from the United Nations Statistical Office. These quarterly bibliographies are put together and published in annual volumes. The same method has also been used for the preparation of an international bibliography covering the ten-year period 1937–1947 which has also been published. The United Kingdom section of this bibliography has been carried back to the year 1900, but the part covering the years 1900–1937 has so far only been issued in mimeographed form. An unpublished paper by Deane (1953*b*), on sources of information for studies of economic growth in the United Kingdom before 1900, contains a selective bibliography of British estimates of national income and wealth prior to 1900. Both this and the United Kingdom bibliography for 1900–1937 can be made available for consultation on application to Miss Deane at the National Institute of Economic and Social Research.

References

ADAMS, A. A. (1953), "The real product of the United Kingdom, 1946–1952", *Times Review of Industry*, Sept. 1953 (London & Cambridge Economic Service).

BARNA, T. (1952), "Input-output study for the United Kingdom in 1935", *J. R. Statist. Soc.*, A., **115**, 29–81.

—— (1953*a*), "Experience with input-output analysis in the United Kingdom", *Input-Output Relations: Proceedings of a Conference on Inter-Industrial Relations held at Driebergen, Holland*, ed. Netherlands Economic Institute, pp. 123–166, Leiden: H. E. Stenfert Kroese N.V.

—— (1953*b*), "International comparisons of national accounts in economic analysis", *Income and Wealth, Series III*, ed. M. Gilbert, pp. 142–155. Cambridge: Bowes & Bowes.

BAXTER, R. D. (1868), *National Income. The United Kingdom.* London: Macmillan.

BOWLEY, A. L. (1937), *Wages and Income in the United Kingdom since* 1860. Cambridge: University Press

—— (ed.) (1944), *Studies in the National Income* 1924–38. Cambridge: University Press.

—— & STAMP, J. C. (1927), *The National Income* 1924 *: A Comparative Study of the Income of the United Kingdom in* 1911 *and* 1924. Oxford: Clarendon Press.

CAMPBELL, A. D. (1954), "Income" in *The Scottish Economy*, ed. A. K. Cairncross, pp. 46–64. Cambridge: University Press.

CARTER, C. F., REDDAWAY, W. & STONE, R. (1948), *The Measurement of Production Movements.* Cambridge: University Press.

—— (1952), "Index numbers of the real product of the United Kingdom", *J. R. Statist. Soc.*, A., **115**, 82–125.

—— & ROBSON, M. (1954), "A comparison of the national incomes and social accounts of Northern Ireland, the Republic of Ireland and the United Kingdom", read to the Statistical and Social Inquiry Society of Ireland and to be published in the *Journal.*

CHAPMAN, A. L. (1953), *Wages and Salaries in the United Kingdom* 1920–38. Cambridge: University Press.

CLARK, C. (1936), *National Income and Outlay.* London: Macmillan.

—— (1951), *The Conditions of Economic Progress.* 2nd ed. London: Macmillan.

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Digitized by Arya Samaj Foundation Chennai and eGangotri

COLQUHOUN, P. (1815), *A Treatise on the Wealth, Power and Resources of the British Empire in Every Quarter of the World, including the West Indies, etc.* 2nd ed. London: Joseph Mawman.
DAVENANT, C. (1699), "Essay upon the probable methods of making a people gainers in the ballance of trade", reprinted in *The Political and Commercial Works of Charles Davenant*, Vol. II, ed. C. Whitworth, London, 1771.
DAWSON, R. F. F. (1953), "Ownership of cars and certain durable household goods", *Bull. Oxford Inst. Stats.*, **15**, 177–191.
DEANE, P. M. (1953*a*), "Regional variations in United Kingdom incomes from employment 1948", *J. R. Statist. Soc.*, A., **116**, 123–139.
—— (1953*b*), "Sources of information for studies of economic growth in the United Kingdom before 1900", read at Third Conference of the International Association for Research in Income and Wealth, Castelgandolfo, 1953 (mimeographed).
GILBERT, M. & KRAVIS, I. B. (1954), *An International Comparison of National Products and the Purchasing Power of Currencies: A Study of the United States, the United Kingdom, France, Germany and Italy.* Paris: O.E.E.C.
HENDERSON, P. D., HOLLAND, D. G. & SEERS, D. (1952), "National income: 3rd quarter 1951", *Bull. Oxford Inst. Stats.*, **14**, 1–15.
—— (1952), "The national income in 1951 and future prospects", *Bull. Oxford Inst. Stats.*, **14**, 45–61.
—— (1951), "The crisis of 1951", *Bull. Oxford Inst. Stats.*, **13**, 305–338.
HOLLAND, D. G. & SEERS, D. (1952), "The paradoxes of 1952", *Bull. Oxford Inst. Stats.*, **14**, 393–422.
—— (1953), "Economic developments in 1952 and future prospects", *Bull. Oxford Inst. Stats.*, **15**, 133–146.
JACKSON, E. F. (1953), "Social accounting in Eastern Europe" (mimeographed), to be published in *Income and Wealth, Series IV.* London: Bowes & Bowes.
KING, G. (1696), "Natural and politicall observations and conclusions upon the state and condition of England", reprinted in *Two Tracts*, ed. George E. Barnett. Baltimore: The Johns Hopkins Press, 1936.
KUZNETS, S. (1951), "Government product and national income", *Income and Wealth, Series I*, ed. E. Lundberg, pp. 178–244. Cambridge: Bowes & Bowes.
LEONTIEF, W. W. (1951), *The Structure of American Economy* 1919–1939. Cambridge, Mass.: University Press.
LYDALL, H. F. (1953), "National survey of personal incomes and savings", *Bull. Oxford Inst. Stats.*, **15**, 35, 193–236, 341–401.
—— (1954), "The methods of the savings survey", *Bull. Oxford Inst. Stats.*, **16**, 197–244.
MARS, J. (1952), "British social income estimates 1938–1950", *The Manchester School*, **20**, 25–56.
MARSHALL, A. (1947), *Principles of Economics: an Introductory Volume*, 8th ed. London: Macmillan.
NICHOLSON, J. L. (1953), "Some problems in the measurement of real national product" (mimeographed), to be published in *Income and Wealth, Series IV.* London: Bowes & Bowes.
PAIGE, D. C., & ADLER, S. (1953), "International comparisons of national product: an approach by industry of origin" (mimeographed), to be published in *Income and Wealth, Series IV.* London: Bowes & Bowes.
PETTY, W. (1690), "Political arithmetick or a discourse concerning the extent and value of lands, people, buildings", reprinted in *Economic Works of Sir William Petty*, Vol. I, ed. C. H. Hull. Cambridge: University Press, 1899.
PREST, A. R. (1948), "National income 1870–1946", *Econ. J.*, **58**, 31–62.
—— (1954), *Consumers' Expenditure in the United Kingdom*, 1900–1919. Cambridge: University Press.
REDDAWAY, W. B. (1950), "Movements in the real product of the United Kingdom 1946–49", *J. R. Statist. Soc.*, A., **113**, 435–463.
—— (1951), "Some problems in the measurement of changes in the real geographical product" in *Income and Wealth, Series I*, ed. E. Lundberg, pp. 267–292. Cambridge: Bowes & Bowes.
REDFERN, P. (1955), "Net investment in fixed assets in the United Kingdom, 1938–53", *J. R. Statist. Soc.*, **118**, 141–182.
SAUNDERS, C. T. (1954), "National income statistics: are they accurate or useful?", *Incorporated Statistician*, **5**, 3–15.
SEERS, D. (1949), "Quarterly estimates of the national income", *Bull. Oxford Inst. Stats.*, **11**, 293–306, 373–381.
—— (1950*a*), "The national income in 1949", *Bull. Oxford Inst. Stats.*, **12**, 74–80.
—— (1950*b*), "The national income: 1st quarter of 1950", *Bull. Oxford Inst. Stats.*, **12**, 138–158.
—— (1950*c*), "The national income: 2nd quarter of 1950", *Bull. Oxford Inst. Stats.*, **12**, 261–270.
—— (1951*a*), "National income: 3rd quarter of 1950", *Bull. Oxford Inst. Stats.*, **13**, 1–16.
—— (1951*b*), "The national income in 1950 and future prospects", *Bull. Oxford Inst. Stats.*, **13**, 88–100.
STAMP, J. C. (1916), *British Incomes and Property: The Application of Official Statistics to Economic Problems.* London: P. S. King.
—— (1937), *The National Capital and other Statistical Studies.* London: P. S. King.
STONE, R. (1947), "Definitions and measurement of the national income and related tables", Appendix to *Measurement of the National Income and the Construction of Social Accounts*, p. 21. Geneva: United Nations.
—— (1951*a*), "Functions and criteria of a system of social accounting", *Income and Wealth, Series I*, ed. E. Lundberg, pp. 1–74. Cambridge: Bowes & Bowes.
—— (1951*b*), "The use and development of national income and expenditure estimates", in *Lessons of the British War Economy*, ed. D. N. Chester, pp. 83–101. Cambridge: The University Press.

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STONE, R. (1954*a*), *The Measurement of Consumers' Expenditure and Behaviour in the United Kingdom*, 1920–38, Vol. I. Cambridge: The University Press.

—— (1954*b*), "Relationship between input-output analysis and national accounting", read at the International Seminar on Input-Output Analysis, Varenna, 1954, and to be published in *Proceedings*.

—— & UTTING, J. E. G. (1953), "The relationship between input-output analysis and national accounting", *Input-Output Relations: Proceedings of a Conference on Inter-Industrial Relations held at Driebergen, Holland*, ed. Netherlands Economic Institute, pp. 195–229. Leiden: H. E. Stenfert Kroese N.V.

Annual Abstract of Statistics No. 91 (1954). London: H.M.S.O.

Bibliography on Income and Wealth, Vol. I, 1937–47, ed. D. Creamer (1952). Cambridge: Bowes & Bowes.

—— Vol. II, 1948–49, ed. P. Deane (1953). Cambridge: Bowes & Bowes.

—— Vol. III, 1950, ed. P. Deane (1953). Cambridge: Bowes & Bowes.

—— Vol. IV, 1951, ed. P. Deane (1954). Cambridge: Bowes & Bowes.

Index of Industrial Production, The, (1952), Studies in Official Statistics, No. 2. London: H.M.S.O.

Measurement of the National Income and the Construction of Social Accounts (1947). Geneva: United Nations.

National and Per Capita Incomes of Seventy Countries in 1949 *Expressed in U.S. Dollars* (1950). New York: United Nations.

National Income and Expenditure (Annual Blue Books from 1952). London: H.M.S.O.

National Income and Expenditure of the United Kingdom (Annual White Papers from 1941–51), London: H.M.S.O. (First five volumes were entitled *An Analysis of the Sources of War Finance and An Estimate of the National Income and Expenditure in* . . . A complete list of the Cmd. numbers will be found on p. 446).

National Income Statistics 1938–48 (1950). New York: United Nations.

Preliminary Estimates of National Income and Expenditure (Annual White Papers from 1952). London: H.M.S.O.

Standardised System of National Accounts, A. (1952). Paris: O.E.E.C.

Statistical Digest of the War (1951), History of the Second World War, United Kingdom Civil Series. London: H.M.S.O.

Statistics of National Income and Expenditure (half-yearly from Feb., 1952), Statistical Papers Series H. New York : United Nations.

Statistics of National Product and Expenditure, 1938, 1947–52 (1954). Paris: O.E.E.C.

System of National Accounts and Supporting Tables, A. (1953). Studies in Methods No. 2. New York: United Nations.

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The Sources and Nature of Statistical Information in Special Fields of Statistics

Population and Vital Statistics

By E. Grebenik

1. *Organization and Legislation*

In this paper we shall confine ourselves to a discussion of the population and vital statistics of Great Britain and particularly of England and Wales. Before the setting up the of the Irish Free State the responsibility for collecting and publishing these statistics in Northern Irleand used to be in the hands of the Registrar-General for Ireland. Since that time the Government of Northern Ireland has performed this function through its own Registrar-General. The vital and population statistics of the Channel Islands and the Isle of Man are also excluded from this review.

In Great Britain itself there are two separate offices concerned with these statistics. In England and Wales the department responsible is called the General Register Office. It was created by the Births and Deaths Registration Act, 1836, and is headed by the Registrar General of England and Wales. In Scotland the work is undertaken by the General Registry Office, set up by the Births and Deaths Registration (Scotland) Act, 1854, and its head is called the Registrar-General for Scotland. Both the Registrars-General are members of the Civil Service, and their appointments are made under the Great Seal. In Parliament, the Minister of Health usually answers questions regarding the work of the General Register Office and the Secretary of State for Scotland speaks for the General Registry Office. It is perhaps worthy of mention that the English Registrar General has traditionally been appointed from among the ranks of the administrative class of the Civil Service and has never been a qualified statistician or actuary. The Registrar-General for Scotland, on the other hand, has in the past on occasions been drawn from the professional members of the Service.

According to the *Imperial Calendar* for 1955 the professional staff of the General Register Office consisted of a Chief Medical Statistician assisted by two Medical Statisticians who are qualified medical practitioners, and one Statistician, who deal mainly with mortality and medical statistics on one side. A Chief Statistician assisted by three statisticians and one Assistant Statistician, on the other, deal with population estimates, census and fertility analysis. The Scottish General Registry Office apparently only contains one professional officer, who bears the title of Superintendent of Statistics.

The separation of England and Wales from Scotland is, of course, a reflection of the differences in legal and administrative structures of the two countries. From the point of view of the user of statistics the fact that figures are collected and published by two different authorities can, however, only be described as an unmitigated nuisance. There is considerable movement of population between the two countries, and Great Britain is the more natural demographic unit. Although the two Registrars-General co-operate to the fullest possible extent, the simple chore of having to look up two sets of figures and to aggregate them before data for Great Britain can be obtained adds greatly to the work. The Scottish Registry Office, with its more limited resources, moreover, is not always able to analyse its statistics in the same detail as can the General Register Office in England. In some cases, therefore, it is impossible to obtain detailed figures for Great Britain as a whole, and there are also some minor, though irritating, discrepancies in definition. There appears to be no national reason why the administration, collection and tabulation of these statistics should not be carried out by one department for Great Britain as a whole, whilst separate data for Scotland and for England and Wales continue to be provided. The publication of the results of the 1 per cent. sample of the 1951 Census of Population for Great Britain as a whole is therefore to be greatly welcomed as a step in the right direction.

It has already been mentioned that the headship of the English General Register Office has never been held by a qualified statistician or actuary. Even William Farr, who has been described as the

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father of English vital statistics never achieved that position. The Statistics Committee of the Royal Commission on Population, whilst not underestimating the importance of the administrative work performed by the General Register Office, nevertheless considered that the most important function of that office lay in the preparation and analysis of vital statistics and therefore recommended that:

> "for the future appointments to the position of Registrar General some experience of and competence in statistical work should be a necessary condition; whilst a formal statistical training, though not essential, should be counted a considerable advantage." (7)

As no vacancy in the office of Registrar General has arisen since that recommendation was made it is impossible to say whether any notice has been taken of it.

The principal duties of the Registrars-General are set out in the Births and Deaths Registration Act, 1953, which consolidated previous legislation, the Marriage Act of 1949, the Census Act, 1920, and the Population (Statistics) Act, 1938. The last two acts apply to Great Britain as a whole. The principal Scottish Act is the Births and Deaths Registration (Scotland) Act, 1854, which has already been referred to.

It will be convenient to consider these duties under three headings, dealing respectively with the Census of Population, vital registration and marriage.

(i) *Census of Population*

The Registrar General has been responsible for the administration and analysis of every Census of Population taken since 1841. In 1841 and 1851 he undertook responsibility for the Scottish census as well, but since that date the function has been performed by the Registrar-General for Scotland. Before 1920 each census was authorized by a special *ad hoc* Census Act in which the questions which appeared on the census form were laid down in a schedule to the Act. In 1920, however, a permanent Census Act was passed, authorizing general censuses to be taken at intervals not more frequent than every five years. It should be noted that no maximum interval between censuses is laid down. Detailed arrangements for the census are made by Order in Council and these orders are subject to parliamentary approval. The Act also enabled the Registrar General to take a special census within the area of a local authority at the specific request of that authority, but this power has never been used, nor has the power to take quinquennial censuses. It may be of interest to note that in 1946 the Royal Commission on Population were advised that it was not clear whether the Act made it possible to take a sample census of either the whole or a section of the population.

The Census Act also makes it incumbent on the Registrar General to provide inter-censal estimates of population.

(ii) *Vital Registration*

The 1836 Act which created the General Register Office also provided for the division of the whole country into a number of registration districts and sub-districts and for the appointment of local Registrars of Births and Deaths who were to work under the general supervision of the Registrar General. It was the duty of the local Registrar to inform himself of and to register every birth and death taking place within his district. The parents of any new-born child or, failing them, certain other persons were obliged to inform the Registrar within 42 days of any birth that had taken place. A similar obligation to report a death within five days of its occurrence was placed on the nearest relative of a deceased person, or failing him, certain other persons. However, the 1836 Act laid down no penalties for failure to register, and vital registration did not become complete until 1874 when failure to register a birth or death was made an offence punishable by a fine. In Scotland the original Registration Act of 1854 provided for penalties for failure to register. The form of birth and death certificate to be issued was laid down by the Acts and the system remained in essentials unchanged until 1926 when the registration of stillbirths was made compulsory. In 1938 concern at the falling birth rate led to the introduction of the Population (Statistics) Act which provided for the addition of a number of questions at the registration of a birth and a death. The system will be described in greater detail below.

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(iii) *Marriage*

The Act of 1836 made it possible for a marriage to be solemnized before a Registrar of Marriages and also enabled such a Registrar to issue a certificate enabling marriages to be performed. But by no means all marriages needed such a certificate. It remained possible for persons to be married by a clergyman of the Established Church without any intervention by a Registrar. However, the form of marriage entry to be provided was laid down by law, and each incumbent was obliged to send a copy of his official marriage register to the Registrar General.

In Scotland the situation was slightly different. Before 1940 there was a distinction between regular and irregular marriages. The latter kind could be entered into without a ceremony of any sort and therefore tended to escape registration completely. A regular marriage, on the other hand, which was a marriage performed by a minister of religion could, since 1854, only be solemnised after production of a Registrar's certificate. This certificate was issued by the Registrar, signed by the minister performing the ceremony and the two parties concerned, and was then returned to the Registrar. In Scotland, therefore, Registrars of Marriages were cognisant of every regular marriage that took place. In 1940 irregular marriages were abolished and it was made possible for persons to be married before a Registrar.

2. *Publications*

(i) *The Census of Population*

It is unnecessary to give a detailed account of the history of the British population census in this place, as such an account has recently been provided officially.(4) Here it will suffice to state that since 1801 a census has been taken in every year in which the last digit is 1, with the exception of 1941. The present method of taking the census dates from 1841—the first census for which the Registrar General was responsible. Previous censuses were directed by John Rickman, whose official position was that of a Clerk in the House of Commons. In these censuses the responsibility for completing the census schedule lay with the enumerators. In 1841, however, the present form of household schedule was introduced, and the responsibility for completing the schedule was placed on the head of the household. Since 1841 the information asked for has gradually increased in scope and complexity, though in principle the method of taking the census has remained the same.

The decennial census is the grand inquest of the nation. It is the only occasion on which everyone resident in the country is required to give an account of himself or herself, and the census data provide the only comprehensive and accurate information about the numbers, location and structure of the population of this country. It is not surprising, therefore, that there is a great deal of competition among different government departments to have questions of interest to them included on the census schedule and that questions vary from census to census. Nevertheless, a number of questions have recurred for so long that they appear to have become permanent features of the census schedule.* These questions are the following:

(i) Sex
(ii) Age.
(iii) Relationship to head of household.
(iv) Marital status.
(v) Birthplace.
(vi) Nationality.
(vii) Occupation.
(viii) (Since 1911) Industry, within which employed.
(ix) Place of work.

In addition, special enquiries may be made at particular censuses. Thus, in 1911 and 1951 a question relating to the fertility of married women was included; in 1921 there was an enquiry into dependency or orphanhood, between 1851 and 1911 attempts were made to ascertain the incidence of certain physical or mental deficiencies, and in 1951 a question relating to the terminal age of full-time education was included for the first time. A synoptic table showing the information asked for in different censuses between 1801 and 1931 is given on pp. 4–5 of the publication referred to.

* No attention has been paid to the information given in the census of population which relates to housing.

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In the British census the *de facto* population resident on census night in a particular area has always been counted and no attempt has been made in the census to estimate the *de jure* population of different localities. In 1931 and 1951 a question relating to usual residence has, however, been included, and this makes it possible to distinguish between the resident and the enumerated population of different localities. No attempt has, however, been made in the census to transfer the numbers of persons who were away from home on census night back to their own home areas.

The census fulfills a large number of functions. The first and most obvious consists of the provision of information relating to the numbers and composition of the population, both of the country as a whole and of different localities. This information is provided in the county volumes which contain, *inter alia* information relating to the *de facto* population tabulated by age, sex and marital status for local authorities down to district level. Figures for the total population of parliamentary constituencies and petty sessional divisions are also provided.

Other sub-groups of the population are given in national tables where the population is broken down by occupation and industry, in combination with age, sex and marital status. These data are indispensable for a study of the structure of the labour force.

It has been a feature of the census since 1841 that the information has been provided on a household schedule, i.e. all persons forming a common household have been enumerated on one form. It has also been customary to ask for data regarding the number of rooms in the dwelling on the same form, and in 1951 questions were included relating to the exclusive or shared possession of certain items of household equipment, such as cooking stoves, W.C.s, sinks and fixed baths.

It is therefore possible to obtain particulars regarding the composition of households in this country from the census, and to trace in outline the relationships between household composition and housing accommodation. It should be emphasized that the information in the census relates to the household, i.e. people sharing a structurally separate dwelling and habitually having their meals in common, and not to the biological family. In this connection, the use of the term "family" instead of "household" in the 1931 census was misleading.

The 1951 county volumes provide data relating to household size in relation to the size of dwelling, but the most detailed examination of household structure is undertaken in the 1 per cent. sample tables of the 1951 census. The analysis there is of such complexity that no tabulation of the complete data will be carried out. A distinction was made between households consisting only of a primary family unit, and composite households. A primary family unit was defined as consisting of the head of the household, his spouse and unmarried children, certain near relatives of the head or spouse and resident domestic servants. Joint households were households in which there were additional members, and within them certain family nuclei, consisting of a married couple and children or a lone parent and children, were separately identified. Tables were provided showing the composition of different households classified by the civil status and age of the head and by various kinds of dependants, and occupation density, and in these tables we have the most comprehensive information so far provided about household structure.

Information relating to birthplaces by place of enumeration yields an estimate of net internal migration between different parts of the country, as well as the number of foreign-born residents.

Mention has already been made of the 1 per cent. sample tables of the 1951 Census. These were constructed so that information on a national scale should be made available within a reasonably short time of the date of enumeration. The tables relate to Great Britain as a whole and to certain large constituent sub-areas, and it is to be hoped that they will become a regular feature of future censuses.

Certain information about fertility available from census data will be discussed below in the section on fertility statistics.

One of the important uses to which census data are put consists of the construction of sub-populations which are used as a base for the calculation of rates. It is only in the census, for instance, that we have accurate and complete data relating to the age and civil status structure of occupational groups and occupational mortality and fertility studies are usually made for three years with the census year as a centre. These are further discussed below. The census population is also used as a base from which population estimates for inter-censal periods are provided for the country as a whole and for constituent sections, and it is also used to assess the accuracy of estimates for the previous decade.

Statistics of the working population and of the occupational structure of the population may also

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be obtained from the census. In 1911 Dr. Stevenson of the General Register Office devised a fivefold classification of occupations which has been widely used to divide the population into social status groups and is often referred to as the Registrar General's distribution into social classes. A fivefold definition is of necessity rather rough and ready, and in 1951 a new division into twelve socio-economic groups was added, though the original fivefold division was retained.

The accuracy and completeness of coverage of the British Census are in general believed to be high. Whilst no sample post-enumeration tests of the completeness of enumeration of the American type have been carried out, the Chief Statistician of the General Register Office has recently given reasons for his belief in the trustworthiness of Census figures (1) (2) and general reports on the census have in the past attempted to assess the quality of response from internal evidence and by comparison with vital registration data. Benjamin and Carrier suggest, however, that the census figures of divorced persons may be subject to appreciable error.

The accuracy of British population censuses has steadily increased, and although it will naturally evolve still further, it is unlikely that the method of census taking will change radically in the near future. It is possible that greater use could be made of sampling procedures and it is likely that further developments in this direction will occur.

(ii) *Mortality Statistics*

These statistics are compiled from information obtained at death registration. Whenever a registered medical practitioner has been present at the last illness of a deceased person it is his duty to issue a medical certificate of death and send this certificate to the registrar of the district within which the death has occurred. The cause of death is stated on the medical certificate. The nearest relative (or failing him, certain other persons) must register the death with the local registrar and supply the following information:

(i) Time and place of death.
(ii) Name and surname of deceased person.
(iii) Rank or profession.
(iv) Cause of death (taken from medical certificate).
(v) Marital status of deceased person (if aged 16 or over).
(vi) If married at death: age of surviving spouse.
For women who have been married at any time.
(vii) Year of marriage.
(viii) If married at death: Duration of marriage in years and months.
(ix) If widowed or divorced at death: Duration of marriage in completed years.
(x) Whether deceased had any children by husband or any former husband.

Information supplied under heads (v) to (x) does not appear in the death register but is required for statistical purposes under the authority of the Population (Statistics) Act, 1938. Where no medical practitioner attended the deceased in his last illness the Registrar, and in certain other defined circumstances, the Registrar or the medical practitioner, must report the death to the Coroner before registration.*

Mortality statistics are compiled from these data, and most of them are published in the medical volumes of the *Registrar General's Statistical Review*. The routine tabulations that are made relate to the number of deaths taking place in different administrative areas and in the country as a whole analysed by age, sex, cause of death (according to the International List of Causes of Death), marital status and certain combinations of these factors. The Registrar General's statistical staff comment on any special features which may deserve attention, e.g. mortality from a special disease.

For the purpose of local statistics deaths are generally transferred back from the place of registration to the place of residence, though this is not always done in the weekly and quarterly returns, which are published with the minimum of delay after the events to which they relate. Certain changes take place when the International List of Causes of Death is revised, and in 1940 in particular there was considerable discontinuity on account of changes in the treatment of joint

* The office of Coroner does not exist in Scotland, and in the circumstances described in the text deaths will be reported to the Procurator Fiscal.

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causes of death. Rough corrections may, however, be made by considering the dual classification published at the time of revision, which is discussed in the Medical Text to the *Registrar General's Statistical Review*.

Comparative mortality indices are published for different areas (based at present on 1938) which show changes in mortality, both general and disease-specific, after changes in age and sex structures have been allowed for.

Certain special types of mortality are treated in greater detail. Infant and neo-natal mortality may be quoted as an example. Originally infant mortality was given per thousand live births taking place in the same year, but as it was recognized that fluctuations in births may affect the infant mortality rate considerably, the rates have since 1940 been calculated per thousand related births, i.e. roughly per thousand births at risk in the calendar year under review. This correction is, however, only important when births fluctuate considerably in successive years. Mortality at very early periods of life is tabulated in very detailed sub-divisions of time, so that the changing gradient of mortality may be adequately studied. It would be useful if a special tabulation of infant deaths could be provided, showing the month of death jointly with the month of birth. Such a tabulation would, however, mean that additional questions would need to be asked at death registration, or else considerable checking would have to be done in the General Register Office's records. Such checking was recently undertaken for the Medical Research Council's Social Medicine Research Unit for a special investigation into infant mortality.(6)

Figures are also provided giving details about the deaths of women who die in childbirth.

The Decennial Supplement to the Registrar-General's Review contains information based on a combination of census information and vital statistics. For mortality the main subjects covered are Occupational Mortality and Life Tables.

Mortality studies by occupation generally make use of information collected for deaths occurring in the three years with the census date as a centre, though in the case of the 1921 census, deaths for 1921–23 were used to avoid distortions in the occupational structure caused by the aftermath of the first world war. For the last census (that of 1951) deaths for the period 1949–53 will be used, though a preliminary analysis based on the 1950 deaths alone has already appeared. In these publications deaths are broken down by age, occupation and certain causes of death, and the figures provide information regarding social class mortality, as the deaths can be related to the population at risk given in the census. In 1931 the deaths of married women were also analyzed by the occupation of their husbands in order to distinguish environmental from occupational factors. British statistics of occupational mortality are highly developed, and although there are inherent difficulties in their interpretation, they are probably unsurpassed by any other country.

The Registrar General's division of the population into social classes was first devised for use in conjunction with statistics of mortality.

Infant mortality statistics, in conjunction with statistics of occupational fertility, provide information about infant mortality by social class.(9)

Official English Life Tables have been calculated on behalf of the Registrar General by the Government Actuary's Department decennially on the basis of deaths in years surrounding the census with census populations providing the numbers at risk. Abridged and less elaborate life tables are published annually in the Registrar General's *Quarterly Returns*.

(iii) *Statistics of Marriage and Divorce*

Statistics of marriage are compiled from copies of marriage entries which are completed by officiating clergymen and registrars. The information given in the marriage register includes the names, ages and civil status of the two parties to the marriage, their addresses and occupations and the occupations of their fathers. In England and Wales a considerable proportion of these entries are made by clergymen whose information about and interest in statistics is limited and the information relating to occupation, particularly to that of the bride and of the spouses' fathers, is so incomplete that no statistics of marriage by occupation are published. An analysis of marriages taking place in England and Wales and distinguishing previous marital status and age is published in the civil part of the Registrar General's *Statistical Review*.

In Scotland, as was mentioned above, no marriage can now take place without the production of a registrar's certificate, and it is believed that information there is better than it is in England.

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But the information that is published is no more extensive than in England, except that rather more detail is provided about the method by which marriages are solemnized.

Divorce statistics in England and Wales are of two kinds. The Lord Chancellor's Department in their annual volume of *Civil Judicial Statistics* publish the total number of decrees of divorce, nullity and judicial separation that are granted by the High Court, distinguishing the matrimonial offences, e.g. adultery, desertion, or cruelty, for which relief is given. But these statistics deal with *cases* of divorce only and no personal details regarding the parties are given.

In the same place statistics are also provided about the number of separation orders granted by petty sessional courts. Such orders which may be obtained with less formality than decrees of divorce relieve the parties from the duty of cohabitation but do not dissolve the marriage, so that they are not free to marry again. Separation orders may be cancelled, but it is believed that in many cases where the parties are reconciled they do not bother to ask the Court to cancel the order, so that these statistics are of limited value.

The extension of grounds on which divorce may be granted and the increasing frequency of divorce has led to increased interest in the subject and it became desirable that more information should be made available about the parties to the divorce rather than about cases of divorce. This information is available on the divorce petitions which are filed in the High Court. Before 1952 only the petitions filed in the London Registry of the High Court were used for statistical purposes, but since that time, partly as a result of the recommendations of the Royal Commission on Population, statistics are based on decrees of divorce, wherever granted. Not all the information given on the petition is used for statistical purposes, but figures are provided in the *Statistical Review* showing divorces, classified by cause, ages of the parties and by age of wife in combination with duration of marriage and the total number of children of the marriage.

(iv) *Statistics of Births, Stillbirths and Fertility*

These statistics are compiled from transcripts of data collected at birth registration. Before 1938 the only information that was asked for when a birth was registered related to the sex of the child, the date of its birth, and (if legitimate) the occupation of its father. However, the preoccupation with the declining birth rate in the 1930's led to the passing of the Population (Statistics) Act, which authorized the collection of additional information at birth registration. This additional information is not entered in the birth register, but is used for statistical purposes only. Data are collected concerning the age of the mother (but not of the father) and, provided the parents are married, the date of the marriage, the number of children born to the mother by the present husband distinguishing the number born alive and still living, the number born alive but now dead, and the number stillborn. If the mother has been married more than once she has also, since 1952, been asked for the date of her first marriage and for details about children born to any previous husbands similar to the details she is required to give about the children born to her present marriage. Similar information is required about stillbirths. These, however, did not become registrable until 1926. Birth statistics are published in the civil part of the Registrar General's *Statistical Review*. They are presented in two parts. The first shows births taking place in different administrative areas, distinguishing between live and stillborn children by sex and legitimacy. In the preparation of these statistics the material collected under the provision of the Population (Statistics) Act, 1938, is not used. The second section of the *Review* analyses maternities by duration of marriage, parity order and mother's age. These statistics are based entirely on information made available by the 1938 Act, and are available only since July 1st, 1938. The analysis is almost entirely in terms of maternities, a maternity being defined as any product of a conception with a period of gestation of at least 28 weeks, i.e. a multiple birth will be counted as one maternity. Order of birth is defined in terms of previous *children*, however. The tables in which fertility is analysed by age of mother show both maternities and births, and it is therefore possible to convert maternities into births.

In most tables duration of marriage is given in single years, for durations up to 10 years and for quinquennial periods thereafter, but in one table maternities are analysed by age of mother and individual years of duration up to 29 years. The first two years are treated in greater detail, durations being given in single months for the first year and for quarters in the second. It should be noted that only the month and year of marriage and birth are used to calculate durations, so that there is an overlap of 'fluffing' of similar duration groups. In 1952 a change was introduced

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which made the published duration of marriage correspond more closely with the real duration, but for the period before 1952 half months should be deducted from the figures as published.

The purpose of all these data is, of course, to make it possible to analyse the fertility of cohorts of women, i.e. women to whom certain vital events happen in a given time period. In this type of analysis there are two possibilities open to the official statistician: he may either take as his cohort the number of women who marry or are born in a given period, say a calendar year, and who have a birth in the year to which the publication relates, or he may take as his cohort women who have a birth at a given marriage duration in a particular calendar year. In the first case the births will be at different durations, in the second the marriages will have taken place in different years. Up to 1952 the Registrar General used the second method of presentation, but there would seem to be certain advantages in the first. If the births taking place were to be tabulated against the year of the mother's marriage, or against the year of her birth (with suitable provision being made for more detailed tabulations in the first year of marriage), it would be possible much more easily to trace a cohort of women marrying in a particular year through successive issues of the *Statistical Review*, and so to obtain an idea of the pattern by which their families were built up. It is gratifying to see that a tabulation by year of marriage was in fact adopted by the General Register Office in 1952. It was, of course, possible to estimate family building patterns from the statistics as presented before 1952, but the process of estimation is an extremely laborious one, as the calculation of the population at risk was much more difficult. Since 1952 the detailed analysis of marital fertility has also been restricted to women who have been married once only, as the records for women married more than once tended to be very deficient.

Special inquiries into the fertility of marriage were undertaken in 1911 and 1951 as part of the general census, and in addition there was the special 10 per cent. sample enumeration undertaken on behalf of the Royal Commission on Population in 1946.

The 1911 inquiry into the fertility of marriage was undertaken as part of the general census. It was a pioneer enquiry and provided the only official data on the fertility of women in the late nineteenth and early twentieth centuries. But it suffered from two limitations; it was confined to women who were still married at the time of the census and who were enumerated on the same census schedule as their husbands, and as no questions were asked relating to the date of birth of the children, the information available about marriages of incomplete fertility was of a limited character. The restriction of the tabulations to women who were enumerated on the same census schedule as their husbands meant, of course, that for marriages of long duration the women included in the tabulation became less and less representative of the marriage cohorts to which they belonged.

Questions on fertility were also asked in the 1951 census, but they were unfortunately limited to married women under the age of 50, presumably because the fertility of older women was adequately covered in the 1946 inquiry. Again no question relating to the dates of birth of the children were asked. The full results of the 1951 fertility inquiry have not yet been published, though preliminary results have been made available in the 1 per cent. sample tables.

The lack of adequate data on marital fertility led the Royal Commission on Population to address an enquiry to a 10 per cent. sample of women who, in 1946, were or ever had been married. They were asked to record their date of birth and marriage, the dates of birth of all their live-born children, and certain information about the social status group of their husband. The tabulations were, however, in the main confined to women who had been married once only and whose marriage was still in existence at census date and to those women whose first marriage had been dissolved by death or divorce at the time of the census, but which had lasted until they had reached the age of 45. As the dates of birth of all their children were recorded in the census it was possible to follow different cohorts of women through their reproductive life and to compare the performance of such cohorts at similar marriage durations, so that marriages of incomplete fertility could be studied as well as marriages in which the woman had reached the end of her productive period.

Statistics of differential fertility may also be obtained from these fertility surveys. In general, fertility differences between different occupational groups are studied, and in both the 1911 and the 1951 fertility censuses, statistics of births by occupational groups of husband were tabulated. In the 1946 survey a slightly more complex classification was used for the husband's social status group, depending on occupation, method of remuneration, and employment status.

It is to be hoped that questions on fertility will be included in future censuses and that it will

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prove possible to include in such censuses the dates of birth of live-born children, so that changes in the fertility of marriage can be traced. Such an undertaking, however, demands very complex tabulation and it will probably be considered sufficient to analyse this type of information on a sample basis, though fairly large samples would be needed for detailed analysis, as the number of cases in individual cells would be small.

Other statistics of differential fertility are available around census time, when birth registration statistics may be tabulated by occupation of father and related to the base population of occupied married males enumerated at the census. These statistics are published in the occupational fertility section of the Registrar General's *Decennial Supplement*.

In 1951 a special question was asked of married women in the census, namely, whether they had a live birth in the twelve months preceding census date. It is expected that occupational fertility tables will be obtained from answers to this question. This method will eliminate difficulties which arise because of differences in stating occupations at the census and at vital registration.

Mention must also be made of the special tabulation of births by father's occupation which was made for the Royal Commission on Population in 1939. These tabulations were analysed by two members of the Royal Commission's staff, Messrs W. A. B. Hopkin and J. Hajnal in *Population Studies*.(3)

3. *Population Estimates and Forecasts. Reproduction Rates*

The Census Act of 1920 requires the Registrar General to make inter-censal estimates of population, and such estimates for the country as a whole and for individual areas are published in the *Registrar General's Statistical Review*. No detailed explanation of the method used in making these estimates has been published. The national estimates have proved to be very near the mark when compared with the census enumeration later; a study of the accuracy of local population estimates which has recently been published suggests that they are accurate within a margin of error of 5 to 6 per cent.(8) The Registrar General uses a number of sources of information in the construction of these estimates, e.g. local birth and death registrations, the parliamentary register which is compiled each year, the number of school children, and the number of new houses brought into occupation may be given as examples. During the period of national registration and food rationing registration data were used as a major item of information, particularly on local movements. In the census year, mid-year estimates of the resident population (i.e. not the *de facto* population given in the census) are given, but these are not broken down by different characteristics.

Population forecasts and projections have since 1949 been published in the December issue of the Registrar General's *Quarterly Return*. One projection only is given, which makes fairly simple and reasonable assumptions, and is carried forward for 40 years. Before 1949 such projections were rarely published officially. The two Registrars-General submitted an estimate to the Royal Commission on the Distribution of the Industrial Population before the 1939 war, and this estimate was later published as a White Paper.(10) The assumptions made were of the simplest and the estimate was severely criticized (5). A large number of projections were made for the Royal Commission on Population and they were published in full in the *Reports and Selected Papers* of the Statistics Committee.

Since 1938 reproduction rates have been officially published by the Registrar General. The gross reproduction rate has been given, and the Registrar General also calculated an effective reproduction rate which combined current fertility data with estimated future mortality. However, this rate was dropped in 1951 in favour of the more conventional net reproduction rate. It was pointed out that mortality had fallen to such an extent that even its complete abolition before the end of the reproductive period would only have led to an increase of 5 per cent., and that the advantages of using current mortality, and thus coming into line with conventional usages, outweighed the gain to be made by trying to estimate future mortality.

An analysis of the generation fertility experienced by cohorts of women born at quinquennial intervals between 1841 and 1931 was published in the Civil Text volume for 1946–50 of the *Registrar General's Statistical Review*.

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References

(1) BENJAMIN, B. (1955), *Pop. Studies*, **8**, 288–293.
(2) —— & CARRIER, N. H. (1954), Paper submitted to the World Population Conference in Rome. (Mimeographed). "An Evaluation of the Quality of Demographic Statistics in England and Wales".
(3) HOPKIN, W. A. B. & HAJNAL, J. (1947), *Pop Studies*, **1**, 187–203, 275–300.
(4) INTERDEPARTMENTAL COMMITTEE ON SOCIAL AND ECONOMIC RESEARCH (1951), *Guides to Official Sources. No. 2: Census Reports of Great Britain:* 1801–1931. London: H.M.S.O.
(5) KUCZYNSKI, R. R. (1943), *The New Population Statistics.* Cambridge: At the University Press.
(6) MORRIS, J. N. & HEADY, J. A. (1955), *The Lancet*, February 12th, 1955, 343–349.
(7) ROYAL COMMISSION ON POPULATION (1950), *Papers.* Vol. II: *Reports and Selected Papers of the Statistics Committee*, p. 24.
(8) SILCOCK, H. (1954), *Pop. Studies*, **8**, 140–147. (See also Mr. Schneider's contribution immediately following.)
(9) TITMUSS, R. M. (1943), *Birth, Poverty and Wealth.* London: Hamish Hamilton.
(10) U.K. MINISTRY OF HEALTH (1942), Cmd. 6358, *Current Trend of Population in Britain.* London: H.M.S.O.

Select Bibliography.

In addition to official publications, reference is made to a number of works by private scholars who have used the official publications provided.

1. *Censuses.*

A complete bibliography of Census publications from 1801–1931 is provided in the Interdepartmental Committee on Social and Economic Research publication entitled *Guides to Official Sources. No. 2: Census Reports of Great Britain:* 1801–1931. London: H.M.S.O., 1951. At the time of writing (June, 1955) the *Preliminary Report* and many of the county volumes of the 1951 census have appeared, as have the 1% *Sample Tables* which were published in two volumes. Cf. also Joyce Bellamy, "A Note on Occupation Statistics in British Censuses", *Pop. Studies* (1953), **6**, 306–308. The fivefold classification of occupation is criticized by D. V. Glass in an Appendix note to Hopkin and Hajnal's paper (see Ref. 6) in *Pop. Studies* (1947), **1**, 296–300.

Reference should also be made to the titles given in Ref. (3) and (7).

2. *Vital Statistics and Population Movements.*

(i) Official

The Registrar-General's Annual Report, 1840–1920.
The Registrar-General's Statistical Review since 1921. Generally published in three parts. Pt. I: Tables, Medical (i.e. relating mainly to mortality); Pt. II: Tables, Civil; Pt. III: Text; but there were variations from this pattern between 1938 and 1950.
Decennial Supplements to the Registrar-General's Statistical Review. (Previous to 1921, *Supplement to the Registrar-General's Annual Report*, starting with the 25th Annual Report.)
Annual Report of the Registrar-General for Scotland, 1855– .
An early account of the system of vital statistics in this country is contained in the series of the League of Nations Statistical Handbooks, entitled *Official Vital Statistics of England and Wales*, Geneva, 1925. In 1953 the General Register Office produced a mimeographed pamphlet entitled *Vital Statistics in England and Wales*, which has not, however, been put on sale.
N. H. CARRIER AND J. R. JEFFERY (1953), *External Migration: A Study of the available Statistics* 1815–1950. General Register Office: Studies on Medical and Population Subjects No. 6. London: H.M.S.O. This contains a large number of tables and some text summarizing information on overseas migration.
D. V. GLASS AND E. GREBENIK (1954), *The Trend and Pattern of Fertility in Great Britain. A Report on the Family Census*, 1946. London: H.M.S.O.

(ii) Unofficial

R. M. TITMUSS (1938), *Poverty and Population*, London, Macmillan, and the same author's *Birth, Poverty and Wealth* (1943), London, Hamish Hamilton, contain an analysis of social class gradients of mortality and infant mortality.
W. P. D. LOGAN (1950), *Pop. Studies*, **4**, 132–178, contains a summary analysis of cause mortality.

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J. W. INNES (1938), *Class Fertility Trends in England and Wales*, 1876–1934, Princeton University Press, deals with differential fertility.

A summary of the 1911 fertility census is given in T. H. C. Stevenson (1920), *J.R. Statist. Soc.*, 83, 1–44.

Three papers in *Political Arithmetic*, edited by L. Hogben, London, 1938, contain an analysis of published statistics. They are:

"Differential Fertility in England and Wales during the past two decades", by Enid Charles and Pearl Moshinsky.

"Changes in Fertility in England and Wales, 1851 to 1931", by D. V. Glass.

"Marriage Frequency and Economic Fluctuations in England and Wales, 1851 to 1934", by D. V. Glass.

A general account of population movements in England and Wales in the ninteenth and early twentieth century is provided in D. V. Glass (1940). *Population Policies and Movements in Europe*, Oxford, Clarendon Press, Ch. 1. The same volume contains on pp. 468–472 a short bibliography of population projections.

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International Statistical Institute, 29th Session, Rio de Janeiro, Brazil, 1955

The 29th Session of the International Statistical Institute was held in Quitandinha, Petropolis, Brazil from June 24th to July 2nd, 1955.

The Session was opened on Friday morning, June 24th, by the Minister of Foreign Affairs, Mr. Raul Fernandes, whose speech of welcome was followed by addresses by Dr. Cardim, President of the Brazilian Institute of Geography and Statistics and Professor Darmois, President of the International Statistical Institute.

The programme for the Session was:

1–2. *The teaching of statistics*
- (1) International experience in statistical education.
- (2) The content of statistical teaching.

3–4. *Statistics of regions within countries*
- (3) General papers.
- (4) Round table discussion of country reports on statistics of regions within countries.

5. *Statistics in economically less advanced countries*

6–7. *Industrial application of statistics*
- (6) The place of statistics in operations research.
- (7) The position of statistics and statisticians in industry.

8. *The application of statistics in the physical sciences*

9. *The statistical basis of economic forecasting*

10–11. *Joint meetings with the International Union for the Scientific Study of Population*

12. *Joint meeting with the International Association for Research in Income and Wealth*

13. *Joint meeting with the Biometric Society*

14–18. *Meetings for the discussion of contributed papers*

Altogether some 150 papers were contributed, printed copies of which will be issued later in a bound volume.

The papers covered a wide range of subjects and only a few can be mentioned here.

(a) *Teaching of Statistics*

There were important papers describing the methods of teaching statistics in different countries, and papers by leading experts on problems involving the teaching of statistics in different fields. A report on the teaching of mathematical statistics is being prepared by the International Statistical Institute for U.N.E.S.C.O.

(b) *Statistical Education*

The Education Centre at Calcutta is being continued and the existence of the Beirut Centre seems now to be assured for some years. Under the auspices of the United Nations and Specialized Agencies a programme has been carried through of statistical education and training in 21 countries, and courses have been attended by 1,600 persons. The Dictionary of Statistical Terms sponsored by the Institute is expected to be published in English before the end of 1955 and will have glossaries in French, German, Italian and Spanish.

(c) *Regional Statistics*

A series of papers was presented on regional statistics collected in different countries and on the problems involved in preparing and publishing such figures.

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(d) *Industrial Applications*

There were papers on the place of statistics in operational research and the position of statistics and statisticians in industry. An *International Journal of Abstracts of Statistical Methods* in industry, started in 1954, has been well received and it is hoped to increase the sale of this Journal.

(e) *A number of interesting papers were presented on the application of statistics in the physical sciences and in experimental work.*

The success of the meeting was certainly due in large measure to the excellent arrangements made by the Brazilian Arrangements Committee, and at the closing meeting a tribute was paid by the President and other members to the care and trouble they had taken.

Although the meeting was held in Petropolis, opportunities were afforded to see something of the country around Rio de Janeiro and to see and hear something of the excellent work being done by Brazilian statisticians. After the Session, lecture courses were arranged in Rio de Janeiro and also in Sāu Paulo.

One of the most pleasant memories of the Conference was to see Professor W. F. Willcox, now in his 94th year, attending meetings and taking an active part. He had made the long trip from New York by cargo boat and on the last Friday took upon himself the arduous task of reading much of the paper by Professor Findlay Shirras who, as Fellows will have since learned with regret, died on his way to the Conference.

The Officers of the Institute for the next two years were elected as follows:

President:	G. Darmois (France).
Vice-Presidents:	M. Boldrini (Italy)
	R. C. Geary (Ireland)
	H. Marshall (Canada)
	M. A. Teixeira de Freitas (Brazil)
Secretary-General:	Ph. J. Idenburg (Netherlands)
Treasurer:	Gertrude Cox (U.S.A.)

Professor R. G. D. Allen, who had previously been Treasurer, was inelegible for re-election under the rules of the Institute which limit the holding of office to six years.

An invitation was accepted to hold the next Session of the Institute in Sweden in the first half of August, 1957. It is also possible that a special meeting in Belgium in 1958 may be arranged.

H. CAMPION.

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REPORT OF THE COUNCIL

For the FINANCIAL YEAR *ended December 31st, 1954, and for the* SESSIONAL YEAR *ended June 22nd 1955, presented at the* ONE HUNDRED AND TWENTY-FIRST ANNUAL GENERAL MEETING *of the* ROYAL STATISTICAL SOCIETY, *held at the London School of Hygiene and Tropical Medicine, W.C.1, on June 22nd, 1955.*

Number of Fellows

THE number of ordinary Fellows continued to increase during the year, passing for the first time the 2,500 level. At December 31st, 1954, the actual number was 2,539, that figure representing a net gain of 51. During 1954 171 Fellows were elected or restored to the roll and 120 were lost by death, resignation or default.

Further elections in the early months of 1955 brought the total number of Fellows at the end of April to 2,580.

The election of 11 Honorary Fellows in 1954 increased their number to 28 at the end of that year, of whom 7 were Presidents of other Societies.

Representatives of corporate bodies or institutions number 115 and that figure is included in the total of 2,539 ordinary Fellows.

Number of Fellows (excluding Honorary Fellows)

Calendar Year	*Losses*		*Elected or Restored to the Roll*	*On the Roll at December 31st*
	By Death	*By Resignation or Default*		
1943	17	44	121	1,139
1944	13	16	159	1,269
1945	18	11	177	1,417
1946	24	32	287	1,648
1947	14	61	263	1,836
1948	17	79	238	1,978
1949	16	87	189	2,064
1950	10	83	222	2,193
1951	21	93	228	2,307
1952	15	89	221	2,424
1953	10	91	165	2,488
1954	14	106	171	2,539

Losses by Death

The Council records with regret the loss by death in the year ended April 30th, 1955, of the undermentioned Fellows:

	Date of Election
Buckatzsch, Eric John Metius	1945
*Cahill, Sir J. R.	1912
*c*Clay, Sir Henry, M.A.	1924
*Debenham, Sir Ernest, Bt.	1920
*cp*Drage, Geoffrey, M.A.	1894
Freeborn, K. L. C., A.M.I.E.E., A.M.I.Struct.E.	1952
*Gates, Chasemore Philip	1904
Hopkins, The Right Hon. Sir Richard, P.C., G.C.B.,	1921
Hughes, Thomas Herbert	1913
Johnstone, James C.	1924
Jones, E. J. Clement, F.C.I.S., F.C.I.I.	1953
Macleod, J. R.	1946
Margulies, Oscar	1943
Rostas, L.	1944
Wilkie, David Henderson	1936

* Life Fellow. *c* Served on Council. *p* Contributed to *Proceedings*.

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Sir Henry Clay was an active worker in and for the Society from the time he came to London in 1930. He was a member of Council for eleven of the twenty years 1931–1951 and on four occasions was a Vice-President. Even after becoming Warden of Nuffield College, Oxford, in 1944, with all the exacting responsibilities entailed in building a new college and recruiting its early members, his interest in the Society did not wane, and it was only after his retirement from the college that he ceased to be a member of Council.

Mr. Geoffrey Drage's name is perhaps best known for its association with the Drage Return of the expenditure on the social services. A man of very wide interests, the three papers he presented to the Society touched only a few of the fields in which he was active. He was elected to the Council in 1895, the year after becoming a Fellow, and served in all for four periods between that date and 1922, as well as being a Vice-President from 1918 to 1920. His paper in 1916, "Reorganisation of Official Statistics and a Central Statistical Office" indicates the investigations which preceded his chairmanship of the Official Statistics Committee in 1919.

Mr. J. C. Johnstone, a leader-writer and special writer on the staff of the *Daily Telegraph* for many years, specialized in economic subjects. To these he brought a mind which found a statistical approach congenial. Although he took no active part in the Society, he valued his Fellowship, and his journalistic work did much to further its aims.

Dr. L. Rostas came to this country with an international reputation when he was invited in 1939 to undertake research under the auspices of the National Institute of Economic and Social Research. His first field was taxation and he was joint author with Professor and Mrs. Hicks of *The Taxation of War Wealth* and with Professor Shirras of *The Burden of British Taxation*. He then undertook the comparison of industrial production, productivity and distribution in Britain, Germany and the United States which brought him into prominence. In 1946 he joined the Statistical Division of the Board of Trade, to which he remained attached in an advisory capacity after his appointment as an assistant director of research at Cambridge in 1951. His contributions to discussions at the Society's meetings will be remembered.

The Council also records with regret the death of Mr. Seebohm Rowntree who, although not a Fellow, was well-known to many Fellows for his contribution to the statistical investigation of social problems over a long period.

Honorary Fellowship

The 11 statisticians of international reputation, mentioned in the Annual Report for last year as being recommended by the Council for election to Honorary Fellowship, were elected at the Ordinary General Meeting on June 23rd, 1954. They were:

Professor F. Bernstein
Professor Harald Cramér
Professor G. Darmois
Professor L. Einaudi
Mr. T. de Freitas
Mr. Herbert Marshall
Professor P. C. Mahalanobis
Dr. Stuart A. Rice
Dr. W. A. Shewhart
Professor G. W. Snedecor
Dr. O. von Zwiedineck-Südenhorst

During the past Session, the Council has considered the desirability of adding to this list further names of leading international statisticians and has accordingly decided to put forward six candidates for election to Honorary Fellowship.

Vice-Presidents

For the Session 1954–55 the President appointed as Vice-Presidents of the Society Professor R. G. D. Allen, Mr. H. Campion, Mr. R. F. Fowler and Mr. R. G. Glenday.

Meetings of the Society

The Council continues to acknowledge its indebtedness to the Board of Management and the Dean of the London School of Hygiene and Tropical Medicine for the use of their lecture theatre for the Ordinary General Meetings of the Society. The papers read during the Session have been:

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1954

November 17th — Lord PIERCY, C.B.E. Presidential Address: The Macmillan Gap and the Shortage of Risk Capital.

December 15th — Discussion on Current Population Problems, opened by B. BENJAMIN, E. GREBENIK, W. P. D. LOGAN, BRINLEY THOMAS, J. HAJNAL, and J. A. FRASER ROBERTS.

1955

January 19th — P. REDFERN, Net Investment in Fixed Assets in the United Kingdom, 1938–53.

February 16th — Discussion on The Teaching of Mathematical Statistics at University Level, opened by E. S. PEARSON, J. WISHART, G. A. BARNARD, M. S. BARTLETT, D. G. CHAMPERNOWNE, and D. J. FINNEY.

March 23rd — A. THOM, A Statistical Examination of the Megalithic Sites in Britain.

April 20th — K. F. LANE, and J. E. ANDREW. A Method of Labour Turnover Analysis.

May 25th — J. O. IRWIN. A Unified Derivation of some well-known Frequency Distributions of Interest in Biometry and Statistics.

The attendances at the meetings have ranged from 65 to 135. The Council regrets that the encouragement given in its Annual Report a year ago to Fellows to offer papers for reading has not met with the response it was intended to provoke. During the past Session the number of papers forthcoming has been barely enough for the meetings held and Fellows are again invited to be less diffident than has been the case in recent years in submitting papers for reading at the Ordinary General Meetings. The Council still regards brevity as a desirable feature and there is no need whatever for prospective authors to assume that the merit of the essay depends on its length.

The Research Section

Mr. E. C. Fieller was re-elected Chairman of the Research Section for the Session, and Dr. C. A. B. Smith was elected Honorary Secretary. Other members of the Committee have been: Mr. N. T. J. Bailey, Dr. G. E. P. Box, Dr. D. R. Cox, Mr. J. Durbin, Mr. J. M. Hammersley, Dr. N. L. Johnson, Dr. K. D. Tocher, and Dr. S. Vajda, with Professor M. S. Bartlett and Dr. D. J. Finney appointed by the Council and Dr. J. O. Irwin an *ex officio* member as Editor of the *Journal*, Series B.

The papers read during the Session have been as follows:

1954

November 3rd — G. E. P. BOX, and S. L. ANDERSEN. Permutation Theory in the Derivation of Robust Criteria and the Study of Departures from Assumption.

1955

January 5th — N. T. J. BAILEY. Some Problems in the Statistical Analysis of Epidemic Data.

March 16th — D. R. COX. Some Statistical Methods connected with Series of Events.

May 11th — Symposium on Linear Programming:
S. VAJDA. An Outline of Linear Programming.
E. M. L. BEALE. On Minimizing a Convex Function subject to Linear Inequalities.
G., MORTON, and A. H. LAND. A Contribution to the "Travelling-Salesman" Problem.

The Industrial Applications Section

The Section Committee which co-ordinates the functions of the separately organized Local Groups and links them with the Society has been constituted as follows: Mr. D. J. Desmond, Mr. Philip Lyle, Mr. G. W. Sears, Mr. N. J. Squirrell, Mr. A. W. Swan, Mr. E. D. van Rest (appointed by the Council); Miss J. Keen, Mr. P. J. Stanley, Mr. M. Whyte (nominated by the 1953–54 Section Committee); together with Mr. A. Stafford Beer, Mr. W. D. Ewan, Mr. A. Glaskin, Mr. D. Gold, Mr. A. Kirk, Mr. B. A. Maguire, Mr. K. Mannaberg, Mr. B. J. A. Martin, Mr. D. J. Page, Mr. R. L. Plackett, Mr. R. B. Rowson, Mr. J. H. Simcock, Mr. A. F. Tout, Mr. J. R. Williams (representing Local Groups).

The following officers were elected by the Section Committee: Chairman, Miss J. Keen; Honorary Secretary, Mr. M. Whyte.

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The Officers of the Local Groups were:

Group	*Chairman*	*Honorary Secretary*
Birmingham and District	Mr. B. J. A. Martin	Mr. K. Mannaberg
Glasgow	Mr. J. C. Eaton	Mr. A. Kirk
Leicester	Mr. A. Glaskin	Mr. A. Bramley
London	Mr. A. F. Tout	Mr. D. J. Page
Merseyside	Mr. R. L. Plackett	Mr. J. R. Williams
North-Eastern	Mr. J. Runcie	Mr. W. J. Ross
Sheffield	Mr. A. Stafford Beer	Mr. B. A. Maguire
South Wales	Mr. R. B. Rowson	Mr. W. D. Ewan

Group Membership on 31st December, 1954, was as follows (comparative figures for 1953 are shown in brackets):

Group	*Fellows*	*Non-Fellows*	*Total*	*Average Attendance*
Birmingham	40 (37)	20 (17)	60 (54)	34
Glasgow	8 (9)	34 (52)	42 (61)	13
Leicester	10 (13)	31 (27)	41 (40)	19
London	121 (116)	74 (74)	195 (190)	51
Merseyside	13 (13)	35 (43)	48 (56)	17
North-Eastern	29 (25)	6 (7)	35 (32)	15
Sheffield	23 (22)	44 (40)	53 (66)	17
South Wales	18 (20)	9 (9)	27 (29)	18
	262 (255)	253 (269)	501 (528)	

Fellows who are stated to be members of the Section are those who wish to be attached to a particular Group for the purpose of voting in its elections and being eligible to serve on its Committee.

The accounts of the Section and its Local Groups for the calendar year 1954, excluding expenditure by the Society in relation to the work of the Section, are summarized below:

Expenditure

	£ s. d.	£ s. d.
Birmingham	25 12 3	
Glasgow	28 4 2	
Leicester	8 11 0	
London	26 2 3	
Merseyside	19 13 11	
North-Eastern	32 8 9	
Sheffield	28 14 1	
South Wales	16 7 2	
Section Committee	24 9 4	
		210 2 11
Carried forward to 1955		86 17 7
		£297 0 6

Income

	£ s. d.
Brought forward from 1953	59 0 6
Grants from Council	238 0 0
	£297 0 6

A one-day Conference on the Use of Statistics in Personnel Management, organized jointly by the London Group of the Industrial Applications Section, the Study Section, the Institute of Personnel Management, and the British Institute of Management, was held at the Connaught Rooms on Friday, November 26th 1954. The Conference, which proved a valuable contribution to the subject, was attended by over 180 delegates, about one-third of whom were primarily statisticians, the remainder being drawn chiefly from the management or personnel fields.

Fifty-four meetings, listed below, were held by local Groups: 7 each in Birmingham, Glasgow, London, Sheffield and Liverpool; 6 each in Leicester and Newcastle-upon-Tyne; 3 in Newport; 2 in Cardiff; 1 in Crumlin; 1 in Harrow; and 1 in Wolverhampton.

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Birmingham and District Group

1954

October 6th — Productivity Studies in the Cotton Industry—L. H. C. Tippett.
October 20th — Visit to G.K.N. Research Laboratories, with an address by Dr. T. Emmerson.
November 3rd — Operational Research during the War—P. M. S. Blackett, F.R.S.
December 1st — Simpler Design of Experiment—R. C. Curnow.

1955

January 5th — Plant Loading and Utilization in Job Production—A. Stafford Beer.
February 2nd — Easy Profitable Applications of Statistics in Industry—M. J. Moroney.
March 2nd — Some Local Statistics—Richard Padley.
April 6th — Annual General Meeting.

Glasgow Group

1954

October 12th — Developments in Operational Research—John C. Eaton.
November 11th — Ratio Delay Techniques—John H. Hepburn.
December 11th — The Use of Graphical Statistics in Steelmaking—D. Hadfield.

1955

January 13th — Operations Research applied to Material Handling—J. Murdoch.
February 8th — Design of Experiments to Secure Process Improvement—G. E. P. Box.
March 10th — Forecasting Sales—Joan E. Keen.
April 12th — Annual General Meeting and Open Discussion

Leicester Group

1954

October 14th — A Multihead Sorting Machine for the Grading of Small Ceramic Components—A. N. James.
November 4th — The Development of a Statistical Investigation—D. J. Desmond.
December 2nd — Audience Research for the B.B.C.—R. Silvey.

1955

February 17th — Forecasting Sales—Joan E. Keen.
March 22nd — A Practical Approach to Making Statistical Decisions—G. A. Barnard.
April 28th — Annual General Meeting.

London Group

1954

October 1st — Statistical Methods and Operational Research in the Motor Industry—A. Hardman.
October 29th — Joint Meeting with the Institute of Cost and Works Accountants, London Branch: Statistics and the Accountant, Part II—A. Muir.
December 3rd — Some Fundamental Problems in the Subjective Appraisal of Foodstuffs—R. Harper.

1955

February 4th — A Multihead Sorting Machine for the Grading of Small Ceramic Components—A. James and D. Boswell.
March 4th — An Application of Monte Carlo Methods to Communication Problems—J. C. R. Clapham.
April 1st — Some Recent Advances in Experimentation to attain Process Improvement—G. E. P. Box.
May 6th — Joint Meeting with the Institute of Metals, London Group: Statistical Methods in Metallurgy—U. R. Evans, F.R.S.
June 1st — Visit to the Kodak Research Laboratories at Harrow.

Merseyside Group

1954

October 5th — Weights and Measures—D. J. Desmond.
November 2nd — The Estimation of Expected Life from Incomplete Forced Life-Test Data—Joan E. Keen.
December 7th — Non-Parametric Tests—G. A. Barnard.

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1955

January 11th Probability in Industry—E. A. G. Knowles.
February 15th Some Experiences in the Economic Assessment of New Industrial Methods—K. P. Norris.
March 15th Linear Programming—N. Williams.
April 19th Particle Size Distributions—G. P. Davies.

North-Eastern Group

1954

October 13th The Development of a Statistical Investigation—D. J. Desmond.
November 10th Figures and Facts—B. P. Dudding.
December 8th The Advertisers' Use of Statistics—P. Harper.

1955

January 19th The Design of Industrial Experiments—N. L. Franklin.
February 9th Process Inspection—E. S. Page.
March 9th Probits and Logits—R. L. Plackett.
March 30th Critical Values of Linear Combinations of Variance Estimates—A. Huitson.

Sheffield Group

1954

September 30th Some Examples of Operation Research in the Coal Industry—B. H. P. Rivett.
October 28th The Analysis and Use of Industrial Data—Joan E. Keen.
November 29th A Mathematical Treatment of Reasons for Failure—K. F. Lane.

1955

January 27th Inventory Control in Firms—K. S. Lomax.
February 24th Smoking and Lung Cancer—Richard Doll.
March 31st Bunching of Furnaces—R. Solt.
April 28th Labour Wastage in an Industrial Concern—J. E. Andrew.

South Wales Group

1954

October 6th Incentives in Industry—L. T. Wilkins.
November 4th Small Particle Statistics—G. Herdan.
December 2nd A Practical Approach to Making Statistical Decisions—G. A. Barnard.

1955

January 12th Sensory Tests in Industrial Research—J. R. Williams.
February 11th Does Normality Matter?—G. E. P. Box.
March 18th Regression Analysis Applied to Air Pollution—J. F. Cutts.
A Problem of Weighting—W. W. Jones.
Some Aspects of the Analysis of Continuous Measurements—K. W. Kemp.
The Approximate Calculation of Errors in Non-orthogonal Experiments—W. D. Ewan.

The Council again records its thanks to the Electric Lamp Manufacturers' Association, the South Wales Electricity Board, Cardiff University and Crumlin Technical College for kindly providing accommodation for meetings.

The Study Section

Mr. J. I. Mason has been Chairman of the Section Committee during the current session. Mr. R. J. Finlayson has been Honorary Secretary. The other members of the Committee were: Mr. B. Benjamin and Miss S. V. Cunliffe (appointed by the Council); Mr. A. Bothwell, Mr. M. P. Curwen (Honorary Secretary of the Study Circle on Medical Statistics), Mr. H. Gearing, Mr. D. L. Lamberth, Mr. C. A. Moser, and Mr. L. T. Wilkins.

Three Committee meetings and the following general meetings have been held in London during the session:

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1954

October 13th — Getting Figures Over—D. E. Locke, R. M. Blaikley and B. Copland.
November 10th — Sales Forecasting: Is it a Science or an Art?—D. J. Liston.
December 8th — The Planning of Field Experiments—D. J. Finney.

1955

January 12th — Statistics in Parapsychology—R. H. Thouless (Guest Chairman, Dr. W. P. D. Logan).
February 9th — Improving Statistics of Retail Trade—W. Rudoe.
March 9th — A Discussion between Users and Producers of Prediction Methods—G. W. Lynch and L. T. Wilkins (Guest Chairman, Miss S. V. Cunliffe).
April 13th — Family Budgets—R. F. Fowler.
May 18th — Demonstration by J. Lyons & Co. Ltd. of their Electronic Office (L.E.O.).

The Committee of the Bristol Group for the session has been as follows: Mr. D. A. Clark (Chairman), Mr. G. M. Clarke (Honorary Secretary), Mr. C. R Hobbs and Mr. H. C. Mackenzie.

Six meetings were held, and the following subjects discussed:

1954

October 21st — The Use and Presentation of Statistics—G. F. Todd.
November 18th — Uses and Abuses of National Income Statistics—R. C. Tress.
December 16th — Amount of Experimentation—D. H. Rees.

1955

January 20th — The Measurement of the Audience for Commercial Television—G. H. Dowson and R. Brook.
February 17th — The Use of Statistics in the Investment of Funds—G. H. Ross Goobey.
March 17th — Retail Trade Statistics—J. Stafford.

Attendances were higher than during last session, the range being from 17 to 38, with an average of 28.

The Committee of the Study Circle on Medical Statistics for the session was as follows: Dr. W. P. D. Logan (Chairman), Mr. M. P. Curwen (Honorary Secretary), Mr. B. Benjamin, Dr. M. A. Heasman, Mr. P. D. Oldham, and Mr. L. T. Wilkins.

The following meetings were held at the Westminster Hospital Medical School:

1954

September 28th — Chairman's Address: Some Developments in National Vital Statistics—W. P. D. Logan.
October 26th — Research in General Practice—J. Fry.
November 30th — The Teaching of Medical Statistics—L. Bernstein.

1955

January 12th — (Joint Meeting with the Study Section) Statistics in Parapsychology—R. H. Thouless.
February 22nd — Medical Field Surveys—A. L. Cochrane.
March 29th — Hospital Statistics: A Discussion of Ends and Means—C. J. Donelan, K. W. Cross, and C. Abel Smith.
April 26th — Some Hypotheses on Coronary Artery Disease—J. N. Morris.
May 31st — Controlled Trials in Medical Research—Papers by P. Armitage, J. Knowelden, and R. F. Wrighton.

Attendances have ranged from 26 to 53.

The Council again wishes to express its thanks to the Electric Lamp Manufacturers' Association, the University of Bristol, and the Dean of the Westminster Hospital Medical School for kindly providing accommodation for the meetings.

Award of the Guy Medal in Gold and in Silver

During the past Session, the Council accepted the recommendation of the Executive Committee that the award of a Guy Medal in Gold shall be considered at intervals of five years, beginning in 1955. In any year other than the quinquennial year nomination for an award of this medal has to be made by at least ten members of Council and is subject to the condition that there are not more than six living holders.

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The Council warmly approved the unanimous recommendation of the Committee appointed for the purpose that the Guy Medal in Gold be awarded to Professor E. S. Pearson, C.B.E., D.Sc., who had been nominated for that honour by reason of the value of his original contributions, alone or in collaboration with colleagues and assistants; to the theory and practical application of statistics, and for his outstanding services to statistical science. Professor Pearson's contributions to mathematical statistics have appeared in the Society's journals over many years and these together with his work as Managing Editor of *Biometrika* since 1936 have established him as a statistician of international reputation.

The Council was also glad to accept the advice of the Executive Committee that an award of a Guy Medal in Silver be made to Mr. D. G. Kendall for his contributions to the *Journals*. In particular Fellows will recall his paper "Some Problems in the Theory of Queues" read to the Research Section and published in the *Journal*, Series B, Part II, 1951.

Dr. D. J. Finney, F.R.S.

It gave the Council much pleasure that during the past Session another of its members, Dr. D. J. Finney, achieved the distinction of Fellowship of the Royal Society. Moreover, very shortly after this announcement there was also published his election to the Royal Society of Edinburgh. Dr. Finney's standing in statistical circles, especially in the field of biological assay, is too well known to require elaboration and these acknowledgments of his work by the wider world of science give rise to much satisfaction that will be shared by all Fellows of the Society.

The Society's Examinations

Twenty-seven candidates for all or part of the Certificate and four for the Diploma presented themselves for the examinations held on March 23rd, 24th and 25th, 1955.

The following Fellows have been awarded the Certificate of the Society:

Avis, Peter Richard David.
Bell, Richard Marmaduke.
Bennett, Gerald Malcolm.
Chai, Fong Chu.
Dixon, Mervin George.
Gribbin, John Denys.
Haynes, Frank Edwin.
Knight, Audrey Yvonne.
Mansfield, Edwin.
Nutting, Reginald Henry.
Poonai, Premsukh.
Shakespeare, William.
Thompson, Frank Pilling.
Turcan, John Raymond.

The following Fellows have been awarded the Diploma of the Society, the specialized field on which one section of the examination was based being given in brackets:

Mansfield, Edwin (Descriptive economics).
Smith, Peter Harold (Industrial experimentation, including quality control).

The Certificate examination was held in one overseas centre, Georgetown, British Guiana.

The Council again records its thanks to the London School of Hygiene and Tropical Medicine for allowing the examinations to be held in its Department of Medical Statistics and Epidemiology, to those Fellows who acted as invigilators, and to the Examinations Committee and others who have helped the Committee in its work. The Committee has consisted of: Mr. B. Benjamin (Chairman), Professor R. G. D. Allen, Professor G. A. Barnard, Mr. H. S. Booker, Dr. G. E. P. Box, Mr. W. J. Corlett, Mr. J. Durbin, Mr. E. C. Fieller, Dr. D. J. Finney, Mr. M. J. R. Healy, Miss R. J. Maurice, Mr. F. A. A. Menzler, Mr. D. Newman, Professor E. S. Pearson, and Mr. A. Stuart.

The Journals

As in recent years, the four parts of the *Journal* Series A were published during the calendar year, while two parts of the *Journal* Series B were also published. The Council is glad to record its continued appreciation of the services rendered by Dr. J. O. Irwin, the Chief Editor of Series B, and of the assistance given by the Editorial Panel which consisted of: Mr. F. J. Anscombe, Dr. P. Armitage, Professor G. A. Barnard, Professor M. S. Bartlett, Dr. D. R. Cox, Dr. H. E. Daniels, Dr. O. L. Davies, Mr. E. C. Fieller, Mr. J. M. Hammersley, Dr. H. O. Hartley, Mr. D. G. Kendall,

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Professor M. G. Kendall, Mr. R. L. Plackett, Dr. C. A. B. Smith, Mr. J. R. N. Stone, Dr. K. D. Tocher, Dr. S. Vajda, Dr. F. Yates,

Reference was made in the Annual Report last year to the efforts of the Editors of the *Journal* Series A to curb the tendency for the *Journal* to increase steadily in size. As a result the number of pages was reduced from more than 600 in former years to less than 500 in 1953. In 1954, however, there was a slight increase of some 30 pages to a total of 516 and although a journal of this size continues to show a very welcome economy in volume when compared with those of earlier years, even this increase deserves attention. The inclination to include a few extra pages of material is one that can be indulged only when the quality of the material permits, and the Editors, acting on the instructions of the Council, are thus compelled to apply an increasingly high standard when considering material for publication. Fellows will have noticed a minor change introduced from the beginning of 1954 since when the volume numbers of the *Journal* are given in Arabic instead of Roman numerals.

The special series of articles dealing with the sources and nature of statistics in given fields has continued under the direction of Professor M. G. Kendall and 3 articles in this series were published in 1954. Sales of the first volume, containing 20 of these papers and published by Oliver & Boyd, continue. In addition to these 20 published collectively, 17 further articles have appeared in the *Journal* or are in the press and about 6 are in contemplation. When these have been completed, it is intended to publish a second volume, and the operation will then be regarded as concluded.

Applied Statistics

Volume 3 of *Applied Statistics* contained 208 pages. The Editor, Mr. L. H. C. Tippett, reports that this is about the right size to deal with the number of articles that are coming forward for consideration. The journal set out to appeal to the interested layman as well as to the statistician, but of the articles submitted the proportion addressed to statisticians tends to be rather high. Articles of more general interest are especially invited.

The financial surplus for the year, allowing for expenses additional to those appearing in the publisher's account, was £166. Within three years *Applied Statistics* has become financially self-supporting. This highly gratifying result is very largely due to the efficient editorship of Mr. Tippett, to whom the Council is glad to express its great appreciation.

The number of subscribers in 1954 was 1,385 of which only 462 were Fellows. There are over 2,500 Fellows and the Council hopes that more of them will support this publication.

During 1954 Dr. D. G. Beech was appointed Assistant Editor and, early in 1955, Joint Editor with Mr. Tippett. The other members of the *Applied Statistics* Committee have been: Dr. O. L. Davies, Mr. R. F. Fowler, Dr. J. O. Irwin, Mr. G. H. Jowett, Mr. Philip Lyle, Mr. C. A. Moser, Dr. C. Nuttall, Mr. E. D. van Rest, Mr. E. Shankleman, and Mr. L. T. Wilkins.

Index to the Society's Journals

There was prepared during the Session a comprehensive index to the *Journals* of the Society covering the years since 1939, which was the latest year included in the last index previously published. The current index thus comprehends Vols. 103–117 of the *Journal* Series A and Vols. 7–15 of Series B, over the years 1940–1953. This index is on sale at a price of 2/6.

List of Fellows

During the Session the Council authorised the issue of a revised edition of the List of Fellows, incorporating changes of address and other amendments known at the end of 1954. The previous List had been issued in 1951 and the need for a new edition had become imperative. In addition to the gains and losses of Fellows, alterations in titles and academic distinctions, there are no less than some 350 changes of address in the course of a year. It follows that in the course of four years the contents of a List of Fellows develop a substantial degree of error.

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Library

Early in the year it was possible to re-open the Library after the transfer of its contents to the new premises. While the physical accommodation is more restricted than before, storage space having to be found elsewhere for a proportion of the books less frequently in demand, the amenities both for readers and for staff are greater and it is confidently hoped that Fellows will make full use of the facilities now that the inconveniences of the removal are over. The Council desires again to record its gratitude to the London School of Hygiene and Tropical Medicine and to Imperial College for the storage space they are providing.

The Librarian and his staff carried through the task of re-housing the Library with the minimum of dislocation of service to readers and borrowers and the Council acknowledges their success with much appreciation.

The following table shows the inevitable contraction in the use of the Library when it was closed in 1953 and 1954:

	1952	1953	1954
Number of Fellows who made requests to borrow books	391	343	339
Number of applications made	1,423	1,319	1,032
Number of volumes borrowed	2,419	2,110	1,509
Number of volumes "on loan" (unavailable) at time of request	195	185	181
Number of volumes not in the Library at time of request	241	174	137
Total number of volumes asked for	2,855	2,469	1,827
Non-serial works added to the Library	594	516	695

Housing

The past Session has been the first complete one in the Society's new premises. Fellows who have visited the present address will themselves have realized the many advantages it has and the staff, as well as those who frequently attend the offices, much appreciate its amenities. In reporting on the present accommodation, the Council cannot improve on what was said at the 21st Anniversary Meeting of the Statistical Society in March, 1855—just a century ago—"The improvement which has been effected in the Library itself, and in the rooms of the Society, is too considerable not to have attracted the attention of the Fellows."

Finance

Abstracts of the Honorary Treasurer's Accounts, viz. the Statement of Income and Expenditure for the year 1954 and the Balance Sheet as at December 31st, 1954, together with the Auditor's Report thereon, are contained in Appendices B, C and D.

Total Expenditure declined from £14,113 in 1953 to £13,633 in 1954. Of this sum, £5,646 represented publication and distribution expenses of *Journals* A and B—a slight increase over the previous year. Salaries and wages amounted to £2,880 compared with £2,862 in 1953. Expenditure on Office and Library equipment was again exceptionally heavy, representing mainly expenditure on further shelving for the Library. Net charges for rent were more than halved, but House Expenses rose and costs of removal to the Society's present premises chargeable in 1954 amounted to £400.

Total Income, excluding Life Composition Fees received during the year, declined from £15,950 to £13,777. Annual subscriptions increased slightly by £162 to £6,401. *Applied Statistics* showed a net surplus of £166, and there was an increase in examination receipts which, however, still fell short of examination expenses. Receipts from sales of *Journals* A and B declined from £4,606 to £4,134, and the excess of publication and distribution expenses over receipts from sales increased from £858 in 1953 to £1,512 in 1954. Expenditure chargeable to the Rockefeller Foundation grant amounted to £1,587 compared with £2,905 in 1953. As a result of the year's operations there was a small surplus of £144.

Composition Fees received during the year fell from £260 to £165. After allowing for the fees of compounders who died during the year or were presumed to have died in previous years

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the Composition Fee Fund, maintained at the total of Composition Fees received from Fellows still living, amounted to £7,646 at the end of the year.

Further capital expenditure in connection with the Society's new premises amounted to £529 and the value at cost of the leasehold premises, after deducting amortization to December 31st, 1954, was £20,273. At the end of the year £425 was added to the Sinking Fund Investment which stands at £1,095. The Benefaction Fund Investment was reduced slightly to £9,554 represented by £11,006 nominal of British Electricity 3½ per cent. Guaranteed Stock 1976–79.

The Council and Officers

Lord Piercy has stated that much to his regret he is unable by reason of his many interests to offer himself for re-election. The Council is very mindful of the guidance it has received during the year from Lord Piercy and of the way in which he has ensured the efficient despatch of the Council's business. He has generously placed at the Council's disposal his wide experience in public affairs, and his year of office has been greatly to the advantage of the Society.

The Council has pleasure in nominating Professor E. S. Pearson as his successor.

Those ordinary members of the Council who now retire are Mr. F. J. Anscombe, Dr. J. O. Irwin, Mr. F. A. A. Menzler, Mr. J. Ryan, Mr. A. W. Swan, and Dr. J. Wishart, to whom the Council offers its thanks for the services they have rendered. After observing the requirements of the Bye-Laws and having considered the suggestions received, the Council recommended that the six vacancies for ordinary members be filled by the election of Mr. E. C. Fieller, Dr. D. Heron, Professor M. G. Kendall, Mr. G. W. Sears, Mr. R. M. Shone, and Mr. J. R. N. Stone. No alternative proposals were received and the Fellows named below will be announced at the Annual General Meeting on June 22nd, 1955, as having been elected President, other officers and other members of Council for the Session 1955–56.

President

Professor E. S. Pearson, C.B.E.

Council

R. G. D. Allen.
P. Armitage.
G. A. Barnard.
M. S. Bartlett.
B. Benjamin.
H. Campion.
D. G. Champernowne.
*Stella V. Cunliffe.
*E. C. Fieller.
D. J. Finney.
R. G. Glenday.
**D. Heron.
Joan E. Keen.
**M. G. Kendall.
W. P. D. Logan.
Sir George Maddex.
C. A. Moser.
E. D. van Rest.
W. F. Searle.
*G. W. Sears.
*R. M. Shone.
J. Stafford.
**J. R. N. Stone.
L. H. C. Tippett.
L. T. Wilkins.
F. Yates.

Honorary Treasurer

R. F. Fowler.

Honorary Secretaries

R. F. George. Philip Lyle. Iris Douglas.

On behalf of the Council,

PIERCY, *President.*

R. F. GEORGE, PHILIP LYLE, IRIS DOUGLAS } *Honorary Secretaries.*

Those marked ** were not Members of Council during the preceding session; those marked * have never served on the Council.

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APPENDIX A

From June, 1954 to May, 1955 inclusive, the candidates named below were elected Fellows of the Society:

Amirayah Armenag Avedis.
Aung, Gyaw Pyu.

Bamfield, Clifford.
Barclay, Robert Reid.
Baron, Donnan Peter.
Bartholomew, David John.
Bhamburkar, Shriniwas Gopal.
Bhatia, Dev Raj.
Bird, Richard Harold Hughes.
Bishnoi, Ratan Lal.
Bolton, Arthur.
Bone, Maurice Riley.
Bradley, Philip Walter.
Brahma, Pulin Bihari.
Broughton, Eric.
Brown, Harry Stephen.
Brown, Thomas William.
Bugden, Alan.
Burgin, Stanley Frank.

Carter, Anthony George Tryon.
Casimir, John Francis Rupert.
Chalak, Nazhat.
Chynoweth, John Derek.
Cole, Alfred Charles.
Cole, Richard Ian.
Connor, Raymond Arthur Walter.
Cooke, Lynette Grace.
Cooper, Harold Park.
Creighton, Stanley Ernest.

Dalal, Homi Pestonji.
Datta, Pramatha Chandra.
Davies, Maurice.
Dean, Desmond Alfred.
Dennis, Keith Ernest Reginald.
Desabie, Jacques-Paul-Marie-Rene.
Douglas, John Lunn.

Elder, Alexander Taylor.
Evans, David.

Ferguson, Norman.
Fisk, Peter Reginald.
Forbes, Donald Hayworth Stacy.
Forsyth, Gordon.
Fox, Norman Willis.
Francis, Oliver James Cladius.

Gaitonde, Sadguri Yeshwant.
Gammon, Jack.
Gielnik, Stefan.
Gilchrist, Warren Garland.
Goodhardt, Gerald Joseph.
Gravelle-Williams, Clifford Howard.
Gray, John Howard.
Griffiths, Oliver Evan.
Grills, Reginald.
Gunter, John Andrew.

Haig, Bryan Douglas.
Haley, Keith Brian.
Haller, Leopold.
Hardy, Lawrence Donald.
Haskey, Henry William.
Harris, George Anthony.
Harris-Burland, William.
Heap, Eric.
Hill, William.
Hodges, Ivor.
Hogley, Bernard.
Holland, Derek Alan.
Hollingsworth, Thomas Henry.
Howell, Vincent Joseph.
Hunt, Charles Frederick.

Jackson, Rex Raymond Philip.
Jackson, William Walmsley Wood.
Jenkins, Gwilym Meirion.
Johnston, Douglas Hugh.

Karthigesapillai, Kularatnam.
Kay, Emile.
Khuri, Faiz Shukri al.
Knight, Audrey Yvonne.

Langshaw, Harold James.
Leach, Kenneth Powell.
Lesser, Richard Humphrey Simon.
Lewis, William Russell.
Llewellyn, John Anthony.
Lochhead, Robert Knight.
Lowden, James Stiven.

McDowall, Alan Robert.
McGloughlin, Thomas Ivor.
McPhee, William Stafford.
Madgwick, Herbert Arthur Ireland.
Mahhouk, Adnam.
Maitland, Douglas William.
Mansfield, Edwin.
Marshall, Dennis Thomas.
Mawson, Peter Alan.
May, Joyce Mary.
Mercer, Alan.
Millner, Kenneth Barton.
Mishra, Chakradhan.
Murfin, John Webster.
Musk, Frederick Irving.

Nightingale, Robert Tuckwood.

Overton, John Charlton.
Outhwaite, Anne Dearnley.

Pacey, Geoffrey Maynard.
Page, Eric.
Palmer, John Wheatley.
Parsons, Geoffrey Leonard.
Pawar, Babasaheb Bhausaheb.
Peries, Herman Eric.

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Phillips, Brian John.
Pollock, Gerard Joseph.
Pomeroy, David.
Porebski, Olgierd.
Potter, Joan McCabe.
Prais, Sigbert J.
Prakash, Aditya.
Priestley, Maurice Bertram.

Rampersad, Frank Budhoo.
Randall, John Douglas.
Rao, Indrakanty.
Robinson, Hilda Annette.
Rothera, Maurice Seymour.
Royce, Norman James.
Rudoe, Wulf.
Rye, Brian.

Schlesinger, Theodore.
Schwarz, Basil Wilfred.
Scott, John Fraser.
Scregg, Sidney.
Scrogg, Cecil.
Sharan, Awadh Kishore.
Sharp, Donald Joseph.
Small, Victor John.
Smith, Ivor John.
Stevenson, Dennis Arthur Roland.
Standing, Norman Henry.
Stanton, John Henry.
Stops, Brian John.
Swaminathan, Muthuswami.
Sweeting, Kenneth.

Thackray, Gordon.
Thatcher, Arthur Roger.
Townson, William Stanley.
Turcan, John Raymond.
Turner, Arthur.
Turner, Graham.

Vincent, Shirley Elizabeth.

Wakefield, William Barry.
Warburton, Norman.
Warden, George.
Warner, Eleanor Joyce.
Weekly, Edward.
West, Bernard Roy.
West, John Vernon.
Wheeler, David James.
White, Michael Sidney Hampden.
Whitting, Ivan John.
Wiggins, George Edwards.
Williams, Colin John.
Wishart, David Matthew Garrick.
Wragg, Alan.
Wronski, Wojciech.

Corporate Representatives

Annable, Roy,	*representing* Hogg and Mitchell Ltd.
Bailey, Richard,	*representing* P.E.P. (Political and Economic Planning).
Bretscher, Jack,	*representing* The Kuwait Oil Co. Ltd.
Burch, Roland Francis,	*representing* Statistics and Intelligence Division, Board of Inland Revenue.
Jacobs, Robert Maurice,	*representing* The Shell Petroleum Co. Ltd.
Leeks, Roger Arthur,	*representing* Kodak Ltd.
Nabb, Harold,	*representing* The South Western Gas Board.
Newbury-Ecob, David Hugh,	*representing* Vauxhall Motors Ltd.
Newman, Paul Guy Foster,	*representing* Aspro Ltd.
Pugsley, N. S. E.,	*representing* Exeter City Library.
Wright, Fergus Chalmers,	*representing* The Federation of British Industries.

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APPEN

STATEMENT OF INCOME AND EXPENDITURE

1953		EXPENDITURE		1954	
£	£			£	£
	670	Rents payable *less* rent received			311
	563	House expenses			735
	2,862	Salaries and wages (including contribution to staff superannuation scheme)			2,880
	250	Pension			250
	42	Insurance			42
	1,593	Office and Library equipment			876
	—	Furniture previously forming part of Benefaction Fund assets now written off			225
	116	Postage and telephone			177
	456	Stationery and miscellaneous printing			479
		Publication and distribution expenses:			
3,741		Journal, Series A (General) and reprints		3,907	
1,723		Journal, Series B (Methodological) and reprints		1,739	
——	5,464			——	5,646
	143	*Applied Statistics — Loss to date*			—
		Library:			
260		Books		246	
200		Binding		130	
——	460			——	376
	175	General Meetings—ordinary and annual			187
	32	Council and committee travelling expenses			12
		Expenses of sections:			
45		Research		47	
246		Industrial Applications		246	
28		Study		38	
——	319			——	331
	60	Guy Medals			9
		Examination expenses:			
84		Printing, stationery, postage etc.		92	
59		Examiners' fees		89	
——	143			——	181
	37	Auditor's fee (1953)			37
	60	Miscellaneous expenses			33
	425	Amortisation of leasehold premises			425
	243	Costs of removal to new premises			400
	—	Loss on sale of Investment			21
	———				———
	14,113				13,633
	1,837	Surplus carried to Accumulated Fund			144
	———				———
	15,950				13,777
	260	Amount carried to Life Composition Fee Fund			165
	———				———
	£16,210				£13,942
	———				———

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DIX B

FOR THE YEAR ENDED 31ST DECEMBER, 1954

1953		INCOME	1954	
£	£		£	£
		Annual subscriptions:		
6,120		Fellowship	6,286	
10		Research Section	8	
99		Industrial Applications Section	92	
10		Study Section...	15	
——	6,239		——	6,401
	50	Contribution from Royal Economic Society		50
	628	Dividends and interest (gross)		758
		Sales of Journal:		
2,762		Journal, Series A (General) and reprints	2,458	
1,844		Journal, Series B (Methodological) and reprints	1,676	
——	4,606		——	4,134
	—	*Applied Statistics* — Surplus for year		166
	33	Sales of other publications		13
	106	Examination receipts: Fees and Sale of papers		151
	500	*Grant from Royal Society*		—
	2,905	Grant from Rockefeller Foundation—expenditure appropriated thereto		1,587
	152	*Surplus from Conferences*		—
	134	Transfer from Life Composition Fee Fund, being fees of compounders known to have died during year and of those presumed to have died in previous years		102
	597	1950 Benefaction Fund—interest on investment		415
——			——	
15,950			13,777	
260		Life Composition Fees received during year		165
——			——	
£16,210			£13,942	
——			——	

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APPEN

BALANCE SHEET AT

FUNDS AND LIABILITIES

1953			1954	
£	£		£	£
		Accumulated Fund:		
6,805		Balance at 31st December, 1953	8,642	
1,837		*Add:* Balance per Statement of Income and Expenditure ...	144	
	8,642			8,786
		Life Composition Fee Fund:		
7,457		Balance at 31st December, 1953	7,583	
260		*Add:* Life Composition Fees received during year	165	
7,717			7,748	
134		*Less:* Transfer to Statement of Income and Expenditure of fees of compounders known to have died during year, and of those presumed to have died in previous years	102	
	7,583			7,646
		Building Fund (per contra):		
1,432		Balance at 31st December, 1953	1,486	
54		*Add:* Income for year	56	
	1,486			1,542
		1950 Benefaction Fund (per contra):		
	30,971	Balance at 31st December, 1953		30,971
		Liabilities and Income held in suspense:		
5,774		Sundry Creditors	2,266	
1,458		Amounts received in advance	1,836	
	7,232			4,102
		Grant from Rockefeller Foundation:		
203		Balance as at 31st December, 1953	885	
3,587		Amounts received during year	702	
3,790			1,587	
2,905		*Less:* Expenditure appropriated thereto	1,587	
	885			—
	56,799			53,047
		Frances Wood Memorial Fund (per contra):		
566		Balance at 31st December, 1953	588	
22		*Add:* Income for year	23	
588			611	
—		*Less:* Prize awarded in 1954	40	
	588			571
	£57,387			£53,618

REPORT OF

I have examined the above balance sheet and annexed statement of income and expenditure December, 1954, and of its income and expenditure for the year ended on that date according to

5, London Wall Buildings,
London, E.C.2.
26th May, 1955.

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DIX C

31ST DECEMBER, 1954

ASSETS

1953 £	1953 £		1954 £	1954 £
	20,118	*Investments*, per schedule attached ... ... (Market Value, 31/12/53 £21,426, 31/12/54 £20,375)		18,483
	1,486	*Building Fund:* Investment, per schedule attached ... ... (Market Value, 31/12/53 £1,365, 31/12/54 £1,461)		1,542
		1950 Benefaction Fund: Leasehold Premises:		
20,839		At cost	21,368	
646		*Less:* Amortisation to 31st December, 1954	1,095	
20,193			20,273	
646		Sinking Fund Investment, per schedule attached (Market Value, 31/12/53 £657, 31/12/54 £1,138)	1,095	
20,839			21,368	
225		*Furniture at cost*	—	
9,855		Investment, per schedule attached ... ... (Market Value, 31/12/53 £10,581, 31/12/54 £10,791)	9,554	
52		Interest accrued	49	
	30,971			30,971
		Current Assets:		
549		Debtors and amounts paid in advance	426	
100		Arrears of subscriptions recoverable (estimated)	100	
195		Interest accrued on investments (gross)	177	
3,380		Balances at banks and cash in hand	1,348	
	4,224			2,051
	56,799			53,047
		Frances Wood Memorial Fund:		
300		Investment, per schedule attached ... ... (Market Value, 31/12/53 £433, 31/12/54 £449)	300	
288		Post Office Savings Bank Deposit	271	
	588			571
	£57,387			£53,618

NOTE.—

No value is placed in the Accounts on—

(a) Journals and other publications in stock.

(b) Books in library.

(c) Pictures, furniture and equipment.

PIERCY, *President.*

R. F. FOWLER, *Honorary Treasurer.*

THE AUDITOR

which, in my opinion, respectively give a true and fair view of the Society's affairs as at 31st the best of my information and the explanations given to me and as shown by the books.

A. RAE SMITH (DELOITTE, PLENDER, GRIFFITHS & CO.) *Chartered Accountant.*
Auditor.

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APPENDIX D

SCHEDULE OF INVESTMENTS—31st DECEMBER, 1954

1953				*1954*		
Market Value £	*Book Value* £		*Nominal* £	*Book Value* £	*Market Value* £
6,790	*5,580*	2½% Consols (Guy Bequest)	10,528	5,580	6,948
1,443	*1,185*	2½% Consols	2,237	1,185	1,476
1,587	*1,324*	3½% Conversion Loan	1,865	1,324	1,634
422	*490*	3½% War Loan	500	490	435
1,433	*1,486*	3% Savings Bonds, 1955–65...	—	—	—
2,625	*2,992*	3% Savings Bonds, 1965–75...	2,970	2,992	2,658
2,000	*2,000*	3% Defence Bonds	2,000	2,000	2,000
165	*100*	British Transport 3% Guaranteed Stock, 1978–88	195	100	170
4,961	*4,961*	British Electricity 3½% Guaranteed Stock, 1976-79	5,152	4,812	5,054
£21,426	*£20,118*			£18,483	£20,375
		Building Fund:			
£1,365	*£1,486*	3½% Conversion Loan	1,650	£1,542	£1,461
		1950 Benefaction Sinking Fund:			
£657	*£646*	British Electricity 3½% Guaranteed Stock, 1976–79	1,155	£1,095	£1,138
		1950 Benefaction Fund:			
£10,581	*£9,855*	British Electricity 3½% Guaranteed Stock, 1976–79	11,006	£9,554	£10,791
		Frances Wood Memorial Fund:			
£433	*£300*	British Transport 3% Guaranteed Stock, 1978–88	513	£300	£449

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PROCEEDINGS OF THE ONE HUNDRED AND TWENTY-FIRST ANNUAL GENERAL MEETING OF THE ROYAL STATISTICAL SOCIETY held at the London School of Hygiene and Tropical Medicine on Wednesday, June 22nd, 1955, at 5.30 p.m.

The Chair was taken by the President, The Rt. Hon. Lord Piercy, C.B.E.

The President presented the Report of the Council for the financial year 1954 and the session 1954–55, and moved that it be received.

During his submission of the Report the President presented the Guy Medal in Gold to Professor E. S. Pearson, C.B.E., and the Guy Medal in Silver to Mr. D. G. Kendall. He also presented Certificates to the successful candidates in the 1955 examinations who were able to be present at the meeting.

The Honorary Treasurer, Mr. R. F. Fowler, presented the accounts and seconded the motion that the Report be received.

On being put to the meeting the Report was formally received.

On the proposal of Dr. Heron, seconded by Mr. Tippett, Sir Alan Rae Smith was unanimously re-elected Auditor of the Society for the session 1955–56, at a fee of fifty guineas.

The President announced that as no alternative nominations had been received the President, Council and Officers for the session 1955–56, nominated as shown on the list already circulated, were duly elected.

The meeting then terminated.

The Annual General Meeting was preceded by an Ordinary Meeting at which the following were elected Honorary Fellows of the Society:

Professor Maurice Fréchet	France.
Gunnar Jahn	Norway.
Professor Paul Lévy	France.
Lowell Jacob Reed	United States.
J. F. Steffensen	Denmark.
Edwin Bidwell Wilson	United States.

The candidates named below were elected Fellows of the Society:

Peter Hutchison Armitage.
Dorothy Gertrude Clegg.
Donald Edward Crisp.
Thomas Stephen Donaghy.
David Alan Hopkins.
Tadeusz Ignacy Matuszewski.
Frank Herbert Miller.
Kenneth Pennycuick.
Christopher Saville O'Donoghue Scott.

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REVIEWS OF STATISTICAL AND ECONOMIC BOOKS

CONTENTS

	PAGE
1.—*Bartlett* (*M. S.*). An Introduction to Stochastic Processes	484
2.—*Hogben* (*L.*). Chance and Choice by Cardpack and Chessboard. Vol. II	485
3.—*Cramér* (*H.*). The Elements of Probability Theory and Some of its Applications	486
4.—*Fisher* (*Sir Ronald*). Statistical Methods for Research Workers. 12th ed.	486
5.—*Hill* (*A. Bradford*). Principles of Medical Statistics. 6th ed.	487
6.—*Wald* (*A.*). Selected Papers in Statistics and Probability	488
7.—*Masuyama* (*M.*). Graphical Method of Statistical Inference	489
8.—*Jensen* (*A.*). A Distribution Model Applicable to Economics	490
9.—*Hyman* (*Herbert H.*). and others. Interviewing in Social Research	490
10.—O.E.E.C. Industrial Censuses in the United States	491
11.—O.E.E.C. Private United States Investment in Europe and the Overseas Territories	492

1.—*An Introduction to Stochastic Processes: with special reference to Methods and Application.* By M. S. Bartlett. Cambridge University Press, 1955. xiv + 312 pp. $8\frac{1}{2}''$. 35*s*.

Nowadays it is becoming increasingly common to investigate the kind of dynamic processes that take place typically in populations of individuals, such as those involving birth, death, genetic mutation, epidemics, etc., by means of so-called stochastic methods. This entails using a mathematical model which contains probability elements as essential ingredients, in contradistinction to deterministic models. Thus for processes taking place in time the deterministic picture envisages the several variables each to have some precise value at every instant, while the stochastic representation admits a whole probability distribution. A suitably chosen stochastic model will inevitably be much closer to reality than its deterministic counterpart, though usually more difficult to handle mathematically. In many cases, especially if populations are large, the simpler treatment is adequate for ordinary purposes such as predicting mean values. But where stochastic means and deterministic values are not the same, as with epidemics and queues for example, and also for investigating the general behaviour of a process in finer detail, the probability treatment is essential.

The scope of such an approach is much wider than the above remarks might seem to imply. The population of individuals concerned need not be specifically biological, and well-known applications in physics include particles subject to Brownian motion, cosmic ray showers, and turbulence in fluids. Another important field of study deals with cyclic phenomena, such as the fluctuation of sun-spot numbers or economic indices, and involves a detailed analysis of the associated oscillatory time series.

Much work, both in theory and in application, has been done on stochastic processes in recent years, and the literature is now considerable. While there are one or two text-books dealing with some of the more abstract mathematical aspects of stochastic theory, a great need has been felt for a comprehensive and authoritative guide to methods of application. This need has now been met by Professor Bartlett, who has already made extensive contributions to the development of the subject.

Professor Bartlett has addressed himself primarily to applied mathematicians and statisticians who wish to acquaint themselves with a broad range of available techniques and to be given some indication of the underlying mathematical theory. The latter is liable to be complicated and so the more abstract aspects have been reserved for fuller discussion in a companion volume which is planned by Mr. J. E. Moyal. Thus the present work, though not intended to be exhaustive, provides a comprehensive account of the applied part of the subject.

The introductory chapter contains a brief account of the elements of probability theory and the properties of distributions, before going on to a general classification of stochastic processes. While the few remarks on basic probability concepts are useful as a general setting they would hardly be adequate for anyone not already to some extent familiar with them, and such a reader will find it essential to consult one of the standard text-books on mathematical statistics.

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The next two chapters rapidly introduce most of the central ideas, dealing first with random sequences for discrete time and then with processes in continuous time. Topics discussed include Markov chains; classification by asymptotic behaviour; renewal processes; recurrence and passage times; and multiplicative chains.

The stage has then been set for a more detailed account of various practical applications of the theory, and the fourth chapter is devoted to several interesting illustrations. Of an enormous number of subjects to choose from some of those picked out are: an insurance problem of the gamblers' ruin type, sequential analysis, elementary queueing theory, various problems associated with the growth of populations, in particular those involving birth, death, migration, genetic mutation and the spread of epidemics.

Chapter 5 returns to more theoretical aspects and deals with limiting stochastic operations such as convergence, differentiation, integration, and difference and differential equations, where the variables concerned are themselves stochastic processes. The discussion is confined to those topics that are essential to a proper understanding and handling of ordinary applications.

Chapter 6 goes more fully into stationary processes, i.e. processes for which the distributions are to some extent invariant under translations of the time axis. The results obtained are related to various problems in communication theory in Chapter 7 and to the correlation analysis of time-series in Chapter 9. It may perhaps depend on personal interest, but it seems preferable to deal with the evolutionary type of stochastic process first, as Bartlett has done, and to follow with a discussion of stationary processes. Perhaps this is because the evolutionary type exhibits the specifically dynamic aspects of a stochastic process in a more vivid way and so more readily catches the imagination.

Finally, the contents of Chapter 8 must be mentioned as they are concerned with the all-important subject of the statistical analysis of stochastic processes, involving questions of inference, estimation, significance and goodness-of-fit tests. Although the usual principles are still valid, they are often more difficult to apply and may need modification, since successive observations are not in general independent of each other.

The book is completed by an extensive bibliography and is well indexed.

Professor Bartlett has managed to incorporate a wide range of theory and applications in a single book of moderate size. Anyone with the requisite mathematical knowledge can gain an entry to the subject by reading the book as a whole. Others, already grounded in the fundamentals, may prefer to concentrate on particular chapters dealing with aspects of special interest to them. Owing to the large number of topics brought together for discussion much of the mathematical analysis is rather abbreviated in form, but as the book is written primarily for applied mathematicians and statisticians this hardly constitutes a serious criticism. There can be no doubt that the book is a substantial contribution to the development of the subject.

NORMAN T. J. BAILEY.

2.—*Chance and Choice by Cardpack and Chessboard . . . Vol. II.* By Lancelot Hogben. London: Max Parrish, 1955. vi + 428–917 pp. 10″. 70*s*.

This second volume follows the same method of treatment as the earlier part of the work. There is the same lavish use of illustration, the same extensive algebraic development, and the same use of somewhat overflorid language. The reviewer unfortunately finds none of these features helpful to an understanding of the subject, so his comments must, to some extent, be biassed.

The present volume contains a varied selection of topics. The first chapter is on "The Algorithms of Summarization" and contains a number of formulae in preparation for the welter of algebra to follow. This chapter includes an introduction to the algebra of expected values, variances etc. The operator E( ) is introduced, however, not as an "expected value" but as "the operation of extracting the grand mean of the cell-scores". The opportunity of emphasizing the distinction between sample value and population parameter is lost. The second chapter applies the methods developed in the first chapter to certain 'Models of Bivariate Universes' including the important Lexis models. In this chapter the "Cardpack and Chessboard" of the title are supplemented by a lottery wheel and the familiar urns.

The next chapter is on "Assumptions underlying the Analysis and Synthesis of Variance". This chapter is a good example of both the virtues and the shortcomings of the book. The author makes crystal clear the necessity for an adequate appreciation of practical conditions, and a corresponding caution in building up a theoretical model. On the other hand, the logical development of the analysis leaves much to be desired.

The next two chapters ("More about Moments" and "Sampling Distributions") develop, somewhat circuitously, the "Significance Tests for Analysis of Variance" which constitute the

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subject matter of the sixth chapter. This is followed by two chapters on multivariate analysis ("Simple Regression and Discrimination" and "Elements of Analysis of Covariance and Factor Analysis") and a rather oddly placed chapter on multinomial distributions and the "so-called chi-square statistic". The argument at the foot of p. 832 in which the epithet "so-called" is justified seems to depend on one's judgment whether the statistic or the (continuous) distribution has prior claim to the words "chi-square".

There is a final chapter with the title "Second Thoughts on Significance" which contains a rapid survey of more recent developments in statistical theory—naturally translated into the author's own inimitable language—and finishing with a section ("The show must go on") which expresses rather grave doubts on the present status of the subject, but concludes that "if convinced that a transvaluation of statistical theory is overdue, accept what limitations intellectual rectitude imposes on its claims with cheerful resignation".

The book provides stimulating reading, but the reviewer cannot recommend it as a text-book to persons seeking an introduction to statistics or probability theory. Rather is it a book to be read after having attained some mastery of these disciplines. The non-mathematical scientist will find the algebra heavy; the mathematician will find the logical development unsatisfying. But it is a book of character and one that cannot be ignored.

N. L. JOHNSON.

3.—*The Elements of Probability Theory and Some of its Applications.* By H. Cramér. New York: Wiley, 1955; Stockholm: Almquist & Wicksells; London: Chapman & Hall. 281 pp. 10″. 56*s*.

This book provides a sound introductory course in probability theory. It is divided into three parts—Foundations, Random Variables and Probability Distributions, and Applications.

The author's approach to the definition of probability is based on the stability properties of frequency ratios, but uses a formal axiomatic definition and regards the observed frequency ratio as "an experimental measurement of the probability corresponding to the true value P". The discussion of the reasons for adopting this definition is rather sketchy though probably adequate for a work of this nature. Incidentally it would be a useful corrective to uncritical employment of the "observed frequency" approach to note that in a long series the relative frequency is bound to change more slowly as the number of trials increases, and that more detailed investigations (e.g. comparison of relative frequencies in different series of increasing length, as suggested by Professor Cramér) are desirable.

The middle part of the book is written extremely clearly and compactly, and is well up to the standard to be expected of the author. It is, indeed, remarkable how much has been included in so small a compass (98 pages). The English reader will find the definition of the p per cent, value, λ_p, of the normal distribution $N(m, \sigma)$ as the value such that $Pr\{|X - m| > \lambda_p \sigma\} = \frac{p}{100}$ rather confusing.

The final section, of comparable length, is in effect a very condensed text-book on statistics. Unlike the more precise probability theory, statistics is not well suited to such concise presentation. Despite the skill of the author, the general impression left by this part of the book is one of over-simplification. Most of the techniques described have, perforce, to be presented in ready-made fashion, with little reference to the underlying ideas and possible practical details. Thus, quality control is dealt with in six pages, and the analysis of variance in seven. While the catalogue of techniques may be useful as a work of reference, there is considerable danger of the student gaining only a superficial appreciation of the subject from such a presentation.

The book is excellently printed, but the price is rather high considering its size and the class of reader—mainly undergraduates—for whom it is designed.

N. L. JOHNSON.

4.—*Statistical Methods for Research Workers.* By Sir Ronald A. Fisher. 12th ed. Edinburgh and London: Oliver & Boyd, 1954. xvi + 356 pp. $8\frac{3}{4}$″. 16*s*.

The numerous editions have changed this work little. Anyone writing a new non-mathematical book on statistical methods might be expected to deal with a number of topics about which nothing (or almost nothing) is said here—the analysis of time series, the treatment of observations obtained by a sequential sampling procedure, quick but "inefficient" statistical methods, the idea of robustness and the possibility of distribution-free methods, the comparison of several means. And a new book might well give a rather different emphasis to the topics that are dealt with—certainly

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less attention to the intraclass correlation coefficient. The book remains essentially an account of the author's conception of statistical methodology as he formulated it thirty years ago. Its continuing interest comes not only from the enormous influence that it has had but from its presentation of a particular well-defined attitude to the subject. There is still the thrill of new discovery in the emphasis on exact tests of significance, especially those connected with the analysis of variance, and on efficiency in estimation. The book is meticulously and forcefully written, in a style that blends obscurity with clarity, vagueness with precision. We are told how we may calculate significance levels and fiducial limits exactly; little is said (and most of that little is open to objection) about what use can be made of these quantities when calculated. It seems to me to be much the most interesting book on methods that a student may read to supplement a mathematical text.

Various changes have been made in each new edition, most of them very slight. The principal changes that have been made since the eighth edition (1941) are as follows:

In Chapter 1, Section 2, a footnote was added in the ninth edition which seems to identify the terms "likelihood" and "power function". In Section 3, a paragraph new in the twelfth edition defines the notion of consistency for small samples. The definition seems to be a definition of what is usually called unbiasedness.

In Chapter 2, a new section (10.1) on transformed frequencies was formed in the ninth edition out of the last part of the old Section 10, together with new material concerned with an ingenious square-root chart for comparing binomial frequencies. In the eleventh edition a reference was added to a paper by F. Mosteller and J. W. Tukey (1949) describing the use of specially printed paper for such charts. This reference is interesting as being the only reference to a paper on statistical methodology, not by Sir Ronald himself, dated later than 1940. No mention is made of it in the index, either under authors' names or under any word in its title.

In Chapter 5, a new section (26.2) on the ratio of means and regression coefficients was added in the tenth edition. A method of finding fiducial limits for such ratios, based on Student's distribution, is illustrated. Difficulties that may occur in finding such limits are not discussed. Sir Ronald has made some further remarks on this subject in his contribution to the recent symposium on interval estimation (this journal, Series B, **16** (1954), 212–213).

In Chapter 7, Section 41, a paragraph new in the twelfth edition discusses the relative convenience, in significant tests, of working with the variance ratio and with its transformed value z.

In Chapter 9, a new section (57.3) was added in the ninth edition on a χ^2 test of homogeneity of evidence from different sources used in estimating the same quantity.

It is remarkable that the price of the book is still almost the same as before the last war.

F. J. ANSCOMBE.

5.—*Principles of Medical Statistics.* By A. Bradford Hill. 6th ed. London: *The Lancet*, 1955. x + 314 pp. $9\frac{1}{2}''$. 10*s.* 6*d.*

Workers in the field of medicine needing guidance in the interpretation of their numerical data have been finding it in Professor Bradford Hill's text-book ever since the first edition appeared in 1937. Since that time there have been changes in the relative importance of different medical indices; in general a move away from indices of mortality towards indices of morbidity. In particular there has been a steady increase in the number of clinical trials of new remedies and a growing realization of their necessity. Developments in chemotherapy have been so rapid that already the number of diseases remaining in which dramatic improvements in treatment may be expected is small. The recognition of the advantages of new treatments will come more and more to depend on well-designed and sensitive experimental trials.

Professor Hill has been closely associated with the growing use of the clinical trial, and was responsible in particular for those concerned with the treatment of tuberculosis which are recognized as classical. It is therefore most useful that in the 6th edition of his book he has added a new chapter on clinical trials, which, as well as describing with great clarity the principles of their design and analysis, contains a masterly discussion of the apparently new ethical problems which they sometimes raise.

In other respects the new edition is little changed. A table of 10,240 random sampling numbers, with instructions for their use, has been added, and some of the illustrative examples have been modernized (by referring to a 1952 death rate, for example, instead of a 1932 one). In his preface the author regrets that he was unable to achieve his ambition of issuing this new edition "revised and greatly reduced". His readers will be content to differ and will welcome it once more "revised and enlarged."

P. D. OLDHAM.

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6.—*Selected Papers in Statistics and Probability*. By Abraham Wald. Edited for the Institute of Mathematical Statistics. New York, London: McGraw-Hill, 1955. x + 702 pp. 10″. 60*s*.

Volumes of collected works, which take up so much space on our library shelves, are usually only of interest to the student of the history of mathematics. Statisticans, though, are particularly fortunate in having two volumes, which are almost collected works, containing papers of two of the leading statisticians of the past quarter century, R. A. Fisher and A. Wald. In both cases the material in the volumes is fresh and vital, and no worker in mathematical statistics can afford to neglect it in his research. The volume under review more nearly deserves to be called the collected works, despite its title, for it contains "most of Wald's research in statistics and probability except for the work included in the books under his authorship". Apart from the books the omissions are slight. The volume has been edited by a committee for the Institute of Mathematical Statistics, which has added a very brief life (one page) and an excellent discussion of the papers (eighteen pages) which "attempts to give some perspective to Wald's work by relating his different papers to each other and to the work of others". The separate papers are not annotated and are printed as they originally appeared. (The editors were lucky here in that all the journals had pages of about the same size, so that the volume has not the massiveness of the other "collected works" referred to.) A complete bibliography of all Wald's writings is included. There is one paper which has not previously appeared in print. The title is "Testing the difference between the means of two normal populations with unknown standard deviations". This contribution to the Fisher-Behrens problem is along the usual Neyman-Pearson lines and the concepts of decision theory are absent. The idea is briefly that any region of rejection of the null hypothesis that the means are equal must be of the form $|\, y/(s_1^2 + s_2^2)^{\frac{1}{2}} \,| \geqslant \varphi(l)$, where $y = \sqrt{N}(\bar{x}_1 - \bar{x}_2)$, $l = s_1^2/s_2^2$, N is the (common) sample size and the remaining notation is standard. Wald discusses the selection of φ and shows that the choice $\varphi(l) = c - c'l/(1 + l)^2$ produces a region of nearly constant size and is uniformly more powerful than the region corresponding to $\varphi(l) = c$. c and c' are constants. It would be interesting to know how the test compares with that developed by Welch and why Wald did not publish this paper.

The discussion reveals an interesting chronological point. Before his arrival in the States Wald's experience had been in mathematics and econometrics. This continued until in the autumn of 1938 he went to Columbia and was introduced to mathematical statistics by Hotelling. During this academic year (1938–1939) Wald wrote a remarkable paper which contains the essentials of his theory of decision functions. The notion of loss function, the introduction of Bayes solutions (but the rejection of *a priori* considerations), the admissible solutions and the minimax ideas are all present. In other words, as far as statistical ideas are concerned, the major part of his 1950 book on Statistical Decision Functions derives from this paper of eleven years earlier. Of course the mathematical developments of the two contributions are very different, and sequential analysis had arrived in the interval to widen the scope of the method. But the important point is that statistical decision theory is statistics as seen by a mathematician and econometrician with but one year's experience of the subject, who had probably never had to give advice to an agriculturist with some data who wanted to know what it meant. With this knowledge we are certainly entitled to ask whether he was right in his view of statistics. The editors of this volume appear to think that he was: they say that "these ideas [in decision theory] can be used to construct a unified general theory of statistics". But sixteen years after the birth of the theory scarcely any applied statistician makes use of the ideas, and books on statistics hardly ever refer to it, and certainly never mention a minimax estimate. It did not take that time for Fisher's ideas to reach the practical man. So again perhaps we can query the correctness of Wald's view, though we must be careful not to minimize the tremendous importance of decision theory. Through it statistics becomes a branch of mathematics and not a collection of results based on the intuition of genius: through it we can understand the rationale behind many statistical techniques. For example, Karlin has recently shown how, within a wide class of distributions, we can justify many procedures with only mild reference to weight functions and prior distributions. Essentially because the complete classes are so small. It explains why, with these distributions, we should take the tail area (and with others we should not!). No: decision theory does not fail, if it fails at all, because of its mathematics but because of its extra-mathematical ideas, about which Wald was so strangely silent.

Indeed by its mathematical consequences we can test the theory. For example one consequence is that a statistician should always use a Bayes solution (strictly, nearly always, but this is a minor gloss). Or equivalently he must act as if he had a prior distribution. This is a complete class theorem in the technical language of the theory. Granted all the standard objections to prior distributions it still seems reasonable that even if it is unknown we should use the same one in analysing two situations where our previous experience and decisions are identical. For example,

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we should not change our prior distribution just because the experimenter changed from a direct to an inverse binomial sampling method. It then follows from Wald's theory that given the result, 3 defectives out of 10, we should reach the same decision irrespective of the sampling method. This result was first pointed out by Barnard, but disagrees with common practice. Which is right? The present reviewer does not know, but many, perhaps most, practising statisticians would protest on being told that they should ignore how the sample was obtained. Is it relevant to know whether the experimenter in telepathy had continued experimentation until he had obtained a particular success ratio (and it happened to involve 1,000 observations), or whether he had decided in advance of experimentation to stop after 1,000 observations? Any theory based on likelihoods, as Wald's, with the proviso about the prior distribution, will not consider it relevant: and it seems one must agree with this if the purpose of the analysis is to reach a decision. But in a theory such as that of confidence intervals or fiducial probability, where the whole sample space is involved, it is very relevant. So perhaps the statistical problems to which a confidence or fiducial interval seems such an attractive answer are not covered by the unifying decision theory. The minimax decision rule does take account of the sample space and hence of the way in which the observations were obtained, but it is not a currently popular solution to the decision problem.

The difficulties mentioned in the above paragraph are not new: they were mostly pointed out by Barnard, who has argued that decision theory and statistical inference are different, though related, subjects. If this is so, what is the purpose of inference? Can we mathematize it as successfully as Wald has decision theory? It seems reasonable to hope that we can and two lines of approach appear possible. It can be claimed that inference is concerned with the modification of our beliefs by experiment; along the lines of Jeffreys, for example. To this we might add considerations of information and argue that we experiment in order to gain information through a change in beliefs. Wald's approach uses a loss function, and attempts to avoid the introduction of prior beliefs. Jeffreys' approach uses prior beliefs but regards losses as irrelevant. A third possibility is to ask if it is feasible to construct a theory which does not refer to either past experience, through prior beliefs, or future action, through a loss function, but tells us what this experiment on its own has to say about an hypothesis. Can we, for example, set up a function $f(H \mid x)$ which describes in some way our confidence or faith in the hypothesis H given the result, x, of the experiment? Can we make fiducial probability as mathematically respectable as Wald made other branches of statistics? Or can we show that Barnard is wrong and decision theory is as unifying as so many believe? Such an approach would seem worthy of attention and would not reduce the importance of decision theory: for we would do well, especially in England, to recognize that many problems that a statistician is concerned with are decision problems and would benefit from some attention being paid to a loss function, and perhaps prior beliefs, instead of to significance levels.

The chronological point also explains why Wald's papers are so heavily mathematical. He was always concerned to prove vigorously, to state precisely. One lemma of his takes ten papers to prove. This is the correct attitude of the mathematician, not the vaguer, but still correct, attitude of the experimenter. Consequently Wald's papers, though often difficult reading, are always clear, in the sense that with patience it is possible to give an unambiguous meaning to a sentence. This is in marked contrast with Fisher, who writes for the experimentalist. It also accounts for the small extent to which Wald's name appears in the popular statistical textbooks where proof and rigor are not at a premium. The brilliant exception to this remark being the likelihood ratio test in sequential analysis which is an outcome of Wald's wartime co-operation with Milton Friedman and W. A. Wallis.

The volume is excellently produced and is a fitting memorial to the man who, above any other individual, raised statistics to the rank of a respectable branch of mathematical learning.

D. V. LINDLEY.

7.—*Graphical Method of Statistical Inference* . . . By M. Masuyama. Tokyo: Maruzen, 1954. ii + 83 pp. 8″. $2.50.

The scope of this unusual little book is narrower than its title implies. It is described on the title-page as a "seminar note", and is a monograph on the use of double square-root paper for rapid statistical analyses. This device seems to have been first suggested by Fisher and Mather (*Ann. Eugen., Lond.*, **12**, 1–23, 1943) in connection with the angular transformation for proportions, and has been developed by Mosteller and Tukey (*J. Amer. Statist. Ass.*, **44**, 174–212, 1949). If, in a series of binomial trials, the numbers of "successes" and "failures" are plotted on the two square-root scales, the resulting point will fall on a circle with radius proportional to the square root of the total number of trials, n. Furthermore, the variance of its distance (round the circle) from the point corresponding to the expected proportion, π, is asymptotically independent of

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both π and n. For large n the distance along the arc may be replaced by the perpendicular distance from the sample point to the radius corresponding to π. Since this distance is approximately normally distributed, an inset scale on the square-root paper enables rapid significance tests to be performed and confidence limits to be set.

The author then gives an ingenious graphical representation of an asymptotically normal transformation for the ratio of two normal deviates. By using a normal approximation to the non-central χ^2 distribution he is thus able to develop a simple graphical approximation to the F-test and its power function. A number of related problems are discussed in some detail, and 33 examples are provided, with full solutions.

The description of the graphical methods is preceded by an extremely neat but very condensed introduction to mathematical statistics, which would provide an excellent "refresher" article for statisticians. The puzzling thing is that this book is based on lectures to science students. It is difficult to know which to admire the more—the mathematical stamina of Japanese scientists, or the teaching ability of Dr. Masuyama, who is one of the most distinguished exponents of statistical methods in Japan. But one is inclined to feel that an author who signs his preface "M²" could never be a dull lecturer.

P. ARMITAGE.

8.—*A Distribution Model Applicable to Economics.* By Arne Jensen. Copenhagen: Munksgaard, 1954. 99 pp. 10″.

The major part of this monograph consists of a development of a system of probability distributions derived from Markov chains: by varying a small number of parameters, the author is able to show that most of the standard distributions are comprised within his scheme. Such a "dynamic" system is offered as an alternative to the "static" system of e.g. Karl Pearson, the suggestion being that agreement between the assumptions of the problem and those of the derivation of the distribution are of primary importance. In emphasizing the problem of causalities the author's attitude differs from that expressed in Pearson's work on distributions in 1895: "the best argument for the generalized probability curve is that it does fit, and fit surprisingly accurately observations of an asymmetrical character".

The author draws attention to an important duality between the distribution of the state of a system after a given time and the distribution of the time when a given state, or group of states, first occurs. Two simple examples of such dual pairs are the Binomial and Pascal distributions, and the Poisson and Erlang distributions.

The economic applications in the shorter section of the work illustrate the usefulness of Markov process models in econometrics. Brief applications are made to sector analysis, the theory of demand, risk theory and traffic programming. In the largest example on risk theory there is demonstrated a direct connection with the problem of the gambler's ruin and the extinction of family surnames.

Within its limited aims, this is an interesting booklet, although not easy to read: it lacks conciseness and is sometimes obscure. It also contains a number of inaccuracies, one of which is on p. 43 where it is implied that the necessary condition given for the "honesty" of the distribution in a pure birth process is not also sufficient.

F. G. FOSTER.

9.—*Interviewing in Social Research.* By Herbert H. Hyman, with William J. Cobb, Jacob J. Feldman, Clyde W. Hart and Charles Herbert Stember. Chicago: University of Chicago Press, 1954. (London: C.U.P.) xvi + 415 pp. 9″. 60*s*.

This book considers the interview as a tool of the social and psychological sciences and is an important contribution to the literature available on the subject. The art of interviewing is studied objectively in both "real life" and experimental situations. The interview form as practised by anthropologists, psychiatrists and other disciplines using the unstructured interview is considered together with the social survey or poll interview of the structured pattern.

The main problem studied is that of interviewer bias. Many results of investigations of this problem are well tabulated and subjected to sound statistical analysis. The general conclusion reached by the authors is that the structured and controlled interview pattern is less likely to give rise to bias than the unstructured form. They discuss the types of question which are more vulnerable to bias than others. The criticism can be made that some of the best investigations are spoilt by using data drawn from "quota" samples. This means that bias in the selection of informants is confounded with interviewer bias as such.

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The studies upon which the book is based are the result of nearly six years of research sponsored by the Joint Committee of the National Research Council and the Social Science Research Council on the Measurement of Opinions, Attitudes and Consumer Wants.

The first chapter begins by quoting several recognized authorities on the interview with conflicting views. It might not be expected that the different disciplines using the interview would agree, but much disagreement is also found within disciplines. Whatever faith the reader may have in the interview in any of its forms is considerably shaken before he completes the chapter. The chapter is well documented and the authors range over a wide field in demonstrating how little is known (as distinct from what may be believed to be known) about this most important tool of the social sciences. They also indicate that difficulties arising from observer error—the problem of reproducibility—are not restricted to the interview. They conclude that they are dealing with one aspect of an almost universal problem. The chapter ends with an analysis of views by 38 different interviewers, on how to handle the interview, and it is at this stage in our reading that we note with some surprise a slight superficial tendency towards agreement on some points.

The second chapter sets out to define the interview situation. Amongst the evidence considered are some interesting comparisons between the interviewers' reactions to specific informants, and the interviewee's reactions to the particular interviewer. It is apparently possible for the interviewer to feel hostile to the interviewee (and vice versa) without the other being aware of it. Informants were asked what they thought the interviewer's own opinions were, these having first been ascertained by the research workers. There was no relationship between the actual disparity in opinion and the perception of disparity. It is shown, however, that interviewers have expectations of the patterns of responses they are likely to receive from informants, and attempts have been made to trace the nature of the evidence upon which these expectations are based.

It is impossible to note all the different facets of the investigation which, extensive as it is, does little more than open up this large subject. The authors are aware of the limitations of their work. They tell us the worst as well as the best, and are not afraid to publish findings unfavourable to themselves.

Other chapters cover "Sources of effect deriving from the interview"; "Respondent reaction in the interview situation"; "Situational determinants of interviewer effect"; "Interviewer effect under normal operating conditions"; and a final chapter deals with the "Reduction and control of error". Appendices give operational details of the experimental work, and there is an extensive bibliography. There are 88 tables which clearly present the results of some of the work and the authors give the significance levels for the appropriate tests.

All who have occasion to use the interview, or who utilize data based on the interview, whether structured or unstructured in form, should read this book and consider its implications for further research.

LESLIE T. WILKINS.

10.—*Industrial Censuses in the United States.* Paris: O.E.E.C., 1955. 143 pp. 9½". 10*s*. (Technical Assistance Mission 77.)

Recent years have seen rapid developments in the techniques of census-taking and in the uses to which the resulting information is put—for national income estimation, for input-output studies, for market research, as well as providing the bench-mark for current statistics. This factual survey of census practice in the United States, taken in conjunction with the previous O.E.E.C. Survey of Industrial Censuses in Western Europe, will be a valuable guide to countries that wish to improve their industrial statistics in an economical manner and with the co-operation of industry. While the trend of development in the United States has not been markedly different from that in the United Kingdom, the report provides a number of pointers to possible improvements in practice in this country.

The most striking point that emerges is the encouraging attitude adopted by American industry towards manufacturing and business censuses. The U.S. Chamber of Commerce has carried out wide-scale propaganda on their behalf. Some industrialists have pressed for greater product detail in censuses. They have co-operated in the introduction of "self-processing" questionnaires whereby the respondent himself makes a number of auditing checks on the consistency of his figures; if business in this country were willing to do likewise, this could lead to economies here.

Despite the support from industry, the forward planning of the censuses is frequently held up by the failure of Congress to authorize the necessary funds each year. The complete Census of Manufactures scheduled to be taken in 1954 had to be postponed on this account.

Considerable care is taken in drawing up the census questionnaire, new questions being "pre-tested" to ensure that they are correctly understood and capable of being answered by at least a substantial majority of firms. However, it appears that, despite American statistical-mindedness, there is still a lack of uniformity in the concepts and categories used by government analysts and

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business accountants. The report does not make it clear whether there is an equal lack of uniformity in the accounting practices of American firms such as prevails here, and which makes it difficult for the census-taker to devise questions that can be readily answered by all firms.

Considerable economies and speedier publication have been achieved through the application of sampling methods. Sampling has been helped by the existence of a separate register of establishments which is maintained for administrative purposes by the Bureau of Old Age and Survivors' Insurance. The existence of this up-to-date register is an important factor in enabling the interval between detailed censuses to be extended to five years with annual sample surveys in between, instead of the previous two-year interval. It appeared that there were still problems of classification of this register; but if these could be solved and the register used to yield periodical statistics of establishments classified by industries and by size, there was a prospect that even the most complete census might be limited to a survey of the large establishments with a sample survey of small establishments in certain trades. Development on somewhat similar lines is under way in the census of production in Great Britain.

The method of processing the census data is described in detail, with emphasis on the scope for mechanization. The development and manufacture of electronic machines within the U.S. Bureau of the Census is in line with its earlier tradition, when in the 1880's the Bureau hired Dr. Hollerith to develop new and quicker methods of tabulation.

The report mentions the development of a Standard Commodity Classification and the publication of a Product Class Manual which is used in the Annual Survey of Manufactures. These have helped in the co-ordination of products and must be of considerable assistance to those who wish to locate information about specific products, a task which can lead to extreme frustration in dealing with U.K. statistics.

The problems of central co-ordination and control of statistics are examined in the report. Although the American scene is more complicated than is likely elsewhere, their experience should serve as a warning of the duplication and waste that can arise from the division of statistical responsibility. Nevertheless, it appears that there is strong resistance to over-centralization, partly through the belief that a centralized system might lack the flexibility to meet the ever-changing requirements for statistics.

J. M. N. MILNE.

11.—*Private United States Investment in Europe and the Overseas Territories.* Paris, O.E.E.C., 1954. 137 pp. 9½". 8*s*.

This Report by an O.E.E.C. Working Party considers the obstacles which restrict the rate of private United States investment in O.E.E.C. countries and their overseas territories, and makes recommendations aimed at expanding investment in the future.

The origin of the Report is set out in its introductory chapter. In 1950 O.E.E.C.'s *Report on International Investment* had made detailed proposals on means of encouraging both private and public investment. During the succeeding years the expansion of private United States investment in Europe which had been hoped for did not materialize—in fact there had been a decline—even though reductions in American Aid to Europe had increased the importance of private investment as a means of ensuring international equilibrium. The Council of the O.E.E.C. therefore decided that the problems should be studied afresh.

Chapter I gives a short statistical analysis of U.S. overseas investment in the last 50 years. In the 1920's New York had become the world's major source of long-term capital. But the confidence of investors was shaken by the 1930 depression, and the flow of capital virtually ceased. Since 1945, net U.S. exports of private capital have reached a level of only half that of the 1920's (in real terms); and a much lower proportion has been directed to O.E.E.C. countries and their dependencies than in 1929.

The Report then considers the attitude of U.S. business towards investment in Europe, and discusses the deterrents—both real and imagined—which may influence business men against investment abroad. The list of deterrents is quite formidable: the risk that capital and earnings cannot be repatriated and that foreign currencies may be devalued, risks of expropriation, political instability and war, "interference" in business activity through the operation of European governments' controls, and taxation "disincentives".

The Report finds that O.E.E.C. countries welcome a larger inflow of American capital, firstly as a means of introducing new technology and raising productivity, and secondly as a source of capital for economic expansion. Nevertheless European countries have retained controls on this inflow and on transfers of earnings, in order to protect their balance of payments, or because they felt that important industries should not fall under foreign domination. The various methods of control are described and an Annex of 81 pages summarizes separately for 19 countries the regulations governing American investment.

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Foremost among the Working Party's conclusions is the belief that Europe must do more to publicize the investment opportunities it offers. Simplification of formalities is also suggested. Whilst the attitude of most O.E.E.C. countries to transfers of earnings and capital is described as "liberal", the Report emphasizes that the confidence of potential investors must be further strengthened by an uninterrupted record of freedom from restrictions. Other recommendations refer to tax incentives as a means of attracting American investment, and the possibility of joint participation by investors from several countries in suitable projects.

PHILIP REDFERN.

Editors' note on a previous review:

With reference to the review of Mr. Norbert L. Enrick's book, *Quality Control, A Manual of Quality Control Procedure Based upon Scientific Principles and Simplified for Practical Application in Various Types of Manufacturing Plants*, which appeared in the *Journal*, Series A General, Volume 118, Part I, 1955, Mr. Enrick writes: "Permit me to call to your attention a quotation out of context, which has been used by Mr. A. W. Swan and which succeeds in putting an entirely different meaning across than the original. In particular, Mr. Swan quotes: 'Frequency distributions are somewhat wearisome to construct', while actually the book says 'Frequency distributions are somewhat wearisome to construct, but their information may be of paramount importance in setting tolerances realistically'. This puts an entirely different emphasis on the statement. . . . There are several mis-statements as to fact in the review, and again by omitting certain essential other facts, the reviewer succeeds in creating the wrong impression. Here I refer to the statements that 'basic theory has almost disappeared' and 'note that theory first appears in Chapter 12'. Actually, theory appears throughout the book, but certain theoretical chapters have been deferred until later, but not without proper reference to them in the earlier chapters".

Mr. Swan has replied: "I regret that Mr. Enrick thinks that I quoted him out of context in regard to frequency distributions, but there are in fact several places in the book, which I do not now have in front of me, where the impression is given that statistical theory is not essential to the quality control engineer and I still hold that there is too little mention of basic theory; also that no real discussion on basic theory appears until later on in the book".

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STATISTICAL NOTES

(1) British Official Statistics

The interim index of retail prices published by the Ministry of Labour and National Service which was 147 in May (prices at June 17th, 1947 = 100) rose to 150 in June and July. The increase in June was due mainly to the higher prices of new potatoes which replaced old ones and to rises in the prices of cooking apples and eggs and in rail and road passenger fares. In July the prices of eggs, bacon and some other food items showed a rise, but this was offset to some extent by a fall in the prices of some vegetables and tea. Separate figures on the same basis (i.e. June, 1947 = 100) are not available for the different groups of commodities, but the following are the figures based on January 15th, 1952 = 100.

Date	*Food*	*Rent and Rates*	*Clothing*	*Fuel and Light*	*Household Durable Goods*	*Miscellaneous Goods*	*Services*	*Alcoholic Drinks*	*Tobacco*	*All Items*
Weights:	399	72	98	66	72	44	91	78	90	1,000
May 17th, 1955	119·8	114·7	96·2	111·4	95·6	101·4	113·9	102·7	100·3	110·6
June 14th, ,,	124·8	114·9	96·2	112·7	95·6	101·5	115·3	102·7	100·3	112·9
July 12th, ,,	125·6	115·0	96·3	113·0	95·8	101·5	115·5	102·8	100·7	113·3

The Ministry of Labour index of weekly wage rates, which was 152 in May (June 30th, 1947 = 100) remained at that figure in June and rose to 153 in July. The principal classes of workers whose rates of wages were increased during the period included iron and steel workers, wool, hosiery and bleaching and dyeing operatives, printing workers, and employees in milk distribution.

The total working population and the numbers in civil employment in the three months ended June, 1955, were as follows:

(Thousands)

	Total Working Population			*Numbers in Civil Employment*		
Date	*Males*	*Females*	*Total*	*Males*	*Females*	*Total*
April, 1955	16,069	7,777	23,846	15,137	7,680	22,817
May, ,,	16,066	7,804	23,870	15,155	7,718	22,873
June, ,,	16,058	7,811	23,869	15,156	7,734	22,890

The numbers of persons on the unemployment registers of the Employment Exchanges in Great Britain fell by 13,000 in June and by a further 26,000 in July. The total of 184,929 in July, 1955, represented 0·9 per cent. of the estimated total of employees. The percentage in the different Regions ranged from 0·4 in the Midlands and North Midlands to 2·1 in Scotland and 1·4 in Wales.

The following is a sex analysis of the figures:

Number of Unemployed Persons on the Registers of Employment Exchanges

Date	*Men and Boys*	*Women and Girls*	*Total*
May 16th, 1955	136,226	87,417	223,643
June 13th ,,	130,334	80,209	210,543
July 11th, ,,	116,690	68,239	184,929

Of the total of 184,929 in July, 50,310 had been unemployed for not more than two weeks, 37,452 for two to eight weeks, and 77,941 for more than eight weeks, while 19,226 were temporarily stopped.

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The numbers of persons absent from work owing to sickness, including self-employed as well as employed, were 876,700 in May, 855,200 in June and 811,400 in July. The numbers of employed persons absent owing to industrial injuries were 57,200, 56,300 and 59,100.

Figures were published in the *Ministry of Labour Gazette* for August relating to the number of young persons entering employment in 1954. The totals were 258,400 boys and 246,600 girls. Of the boys, 212,000 and of the girls 201,500 were aged 15. About one-third of the boys of this age entered employment as apprentices or learners to skilled crafts and about 5 per cent. entered clerical employment. Nearly one-half of these boys went into manufacturing industries, 15 per cent. went into the distributive trades and 15 per cent. into mining and quarrying. Nearly one-half of the girls aged 15 went into manufacturing and about one-third into the distributive trades.

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(2) Other Statistics

The United Nations has recently published its seventh report on the World Economic Situation, *World Economic Report* 1953–54 (163 pp., 12*s.* 6*d.*). Part I describes the changes in economic conditions in three groups of countries (private enterprize economies; centrally planned economies; and economically under-developed countries); Part II analyses changes in international trade and payments. The outstanding feature in world economic development in the period was the depression in the United States which began in the fall of 1953 and lasted throughout most of 1954. The national product is estimated to have fallen by 3 per cent. in North America but to have risen by nearly 6 per cent. in Western Europe. Thus, contrary to expectation and to previous experience, the decline in North America hardly affected other countries. The volume of world trade in 1954 surpassed the peak of 1953; the value of exports (in constant dollar prices) is estimated as 7 per cent. higher than in 1953. In the centrally planned economies, there was a shift from investment to consumption; in the U.S.S.R. industrial production increased by 13 per cent., slightly more than in 1952 and 1953. A special introduction pays attention to the various factors tending to limit the expansion of world trade. Four supplements to the Report deal with the Economic Development in The Middle East; a Review of Economic Activity in Africa 1950–54; the Scope and Structure of Monetary Economies in Tropical Africa; and the Quest for Freer Trade.

The third and latest Year Book of the International Tin Study Group (*Tin, tinplate and canning: The Statistical Year Book* 1954, £2 15*s.* post free from The International Tin Study Group, 7, Carel van Bylandtlaan, The Hague, Holland) contains many statistical data of practical value to the tin, tinplate and canning trades. In 1954 the International Tin Agreement was signed by the five leading producing countries, namely, Malaya, Bolivia, Indonesia, Belgian Congo and Ruanda Urundi, Thailand and Nigeria, and by fourteen consuming countries, including the United Kingdom, France, Canada and the Netherlands, but not including the United States or the Soviet Union. This leading example of an International Commodity Control Agreement, with its proposals for a buffer stock for the control of exports and for action to be taken in the event of tin shortage, makes the 1954 Year Book an important work of reference for industrialists and economists. The objectives of the Agreement are to prevent excessive fluctuations in price and to ensure adequate supplies. Figures relating to production, imports and exports of tin, tinplate, tin alloys and canned goods are given country by country for 112 countries and in most cases the figures cover the last five or ten years to 1953. In the Sections of the Year Book devoted to individual countries, the data provided for Malaya, which has recovered a large part of its previous importance as a leading producing country, include an excellent summary of the extent of the tin ore deposits. The methods of mining, the power employed, the concentrate output of the companies labour employed (tin mining employs about 90 per cent. of the mining labour force in Malaya), financial aid, smelter production and the canning and tinplate position are described. Tin prices for Singapore are given in miscellaneous tables together with the course of prices in London from 1871 to 1953 and in New York from 1901 to 1953 and reflect the higher costs and the inflationary tendencies of recent years.

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Among the consuming countries, twenty-three tables of statistical information are devoted to the industry in the United States, which is the largest consumer of primary tin in the world. It is also the largest producer and exporter of tinplate and the largest producer and consumer of canned goods. The world tin shortage ended before 1949 and in the following years a substantial excess of world production over commercial consumption was shown. These excesses did not turn into a burdensome surplus because of the buying activities of the U.S.A. strategic stockpile which for tin was completed before the end of 1953. Although tin has been mined for over two thousand years in Cornwall, and from 1860–80 to 1933 has fallen from 9,000 tons (tin content) a year to 1,000 tons, the United Kingdom has considerable importance in the tin smelting industry and at present produces one-sixth of the world's metal, obtaining large supplies of concentrates from Nigeria and other sources. The United Kingdom produces one-eighth of the world's tinplate and is the second largest exporter. This country is the world's greatest importer of canned foods and fruit, although the general trade position has been distorted by the War and by currency difficulties. Twenty-eight statistical tables are devoted to production and trade aspects of the United Kingdom tin industry.

The Year Book has, as Appendix, an English-French Glossary of technical terms. The book terminates with some estimates of the import, export, production and consumption of tin, tin alloys, and tinplate in the Soviet Union, for which no official figures are available.

CURRENT NOTE

The Trustees of the Houblon-Norman Fund invite applications for Fellowships or Grants in aid of Research into the working of industry and finance in Great Britain and elsewhere and the economic conditions affecting them.

Fellowships, which are intended for experienced research workers, are awarded for full-time research for one year, which may be renewed for a second year. Grants are awarded for either full-time or part-time work. The amount of the awards, which will take effect from October 1st, 1956, will depend upon the circumstances of the candidate and the probable expenses of his work.

Candidates must be British subjects normally resident in the United Kingdom.

Forms of application, which may be obtained from the Secretary of the Fund, c/o the Bank of England, London, E.C.2, should be returned not later than March 1st, 1956.

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OBITUARY

Philip Lyle

Philip Lyle was born in 1885 and died on July 15th, 1955. He was educated at Rugby and later at a school in Switzerland. In 1906 he joined the sugar refining business that later became part of Tate and Lyle Ltd., and was a director of that firm until his end.

Such are the bare bones of Philip Lyle's life and career, but for Fellows of the Royal Statistical Society there is much more to be said. First, let us consider his work in statistics. He denied any claim to be either a statistician or a mathematician; but he understood statistical methods and knew how to apply them, and many practising statisticians would envy his competence in mathematics. He seems to have been led to statistics through trying to apply mathematics to the practical problems of his industry. He met the problems first, and then sought solutions where he could—largely in statistical methods.

One of his main statistical interests found expression in his book *Regression Analysis of Production Costs and Factory Operations*, first published in 1944. This is a very individual exposition of regression analysis (characteristically, he wrote in the preface "if in the following pages I appear to have laid undue stress on certain points, it is because they are the ones that gave me most difficulty when I was trying to learn the subject") combined with a convincing picture of the method in action. The acceptability and influence of the book may be measured by the fact that the first edition was sold out within fifteen months of publication, and the second within three years of its publication in 1946. A third, revised, edition was under consideration at the time of his death.

Characteristic of Philip Lyle's work are his two articles "The Construction of Nomograms for Use in Statistics", published in *Applied Statistics* (1954, **3**, Parts 2 and 3, pp. 116–125 and 184–195). The main purpose of the articles is to show how to construct nomograms of empirical formulae (note the practical bias); the chief illustration is concerned with presenting the results of a factorial experiment as a nomogram (note the originality of the application); and reference is made to nineteen papers and treatises, one dating back to 1846 (note the interest of the mathematical scholar). He was interested in the mathematics behind statistics and years ago he spent a holiday at Monte Carlo studying how the laws of probability worked out on the gaming table. The account of this experience which he recently undertook to write for *Applied Statistics* will now, alas, never appear. In sum, Philip Lyle may be described as a distinguished amateur in statistics—as were Galton, Sheppard, and Gosset. May we never become so professionalized that there is no room for such amateurs.

Philip Lyle's main professional interest was, of course, in the business and technology of sugar refining, and it was natural that he should contribute the paper on "The Sugar Industry" in the series "The Sources and Nature of Statistical Information in Special Fields of Statistics" (*Journal*, Series A, 1950, **113**, Part IV, pp. 531–543 and reissued in the volume published by Messrs. Oliver & Boyd).

He was a great supporter of our Society and found happiness in its service and fellowship. It is curious that he did not become a Fellow before 1946, but he soon occupied his rightful positions in the Society. He was elected to the Council in 1947, was on the Executive Committee from 1948 to 1950, and since 1950 had been a Joint Honorary Secretary. He was a Vice-President for the years 1952–53 and 1953–54, a member of the Industrial Applications Sections Committee from 1950 to 1955, of the Applied Statistics Committee from its inception in 1951 until 1955, and of the House Committee for the one session of its existence, 1953–54.

The high confidence in which he was held made him especially effective as a link between the Industrial Applications Section and the Council, advising the Section Committee on what would "go down" with the Council, and then backing the Committee's proposals before Council. His influence contributed much to making the Section a part of the Society in fact as well as in name.

Philip Lyle led us to our fortunate choice of the publishers of *Applied Statistics*, and his counsel and support were also invaluable in the commercial decisions that had to be recommended to Council. It was laid down that the journal had to pay its own way. How big should it be? How many subscribers were there likely to be? What price should be charged? How many copies of the first issue should be printed? Philip derived from estimated costs supplied by the publishers a formula giving the costs and revenue for different numbers of pages, numbers of subscribers, prices, and numbers of copies printed, and from the tables evaluating the formula

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we were able to see the effects of various assumptions. Looking back, I would say that our assumptions were surprisingly good. Perhaps we were lucky; but if there was any element of good judgment in the result, it was owing in no small measure to Philip Lyle. To the first editor of the journal, however, even more valuable was the moral support and advice Philip gave in the first months, when many decisions had to be taken. Perhaps the decisions were of the kind the business man is used to taking and perhaps Philip's business experience especially fitted him to be helpful in the situation; whatever the explanation, it was a great comfort for the editor to have such a steadfast supporter and adviser behind him.

Philip Lyle also took a leading part in the re-housing of the Society—the choosing of new premises, the conducting of negotiations with various parties and the organization of the move, particularly of the library.

Those of us who came into contact with him over the society's affairs had a great affection for him. He was good company, as members of the Dining Club especially know. He was entirely disinterested in his helpfulness, ready to undertake humble tasks and perform them quickly. He was modest to a fault—no pernickety editor had a more amenable or co-operative author than had the editor of *Applied Statistics* in Philip Lyle when the articles already referred to were in the course of preparation.

Of his family life we had occasional glimpses; they indicated complete happiness—one of his sayings was that grandparents have much of the fun of parenthood with none of its responsibilities. He was full of verve, and as he would have wished, lived an active life right up to his last short illness. We mourn the loss of a good friend as well as a devoted servant of the Society.

L. H. C. TIPPETT.

The following is an extract minute of the meeting of the Council held on October 13th, 1955:

> "The Council received with deep regret notice of the death of Mr. Philip Lyle which occurred on July 15th. His services as a member of the Council since 1947 and as an Honorary Secretary since 1950 were recalled with keen appreciation. During these years he devoted considerable time and careful thought to the Society's affairs. He was closely concerned with the launching of *Applied Statistics* and did much to ensure its establishment in the short space of three years. While he was never one to force his views, he was always ready to join in consultation with others. His wise counsel was particularly evident in the assistance he gave some two years ago when the new premises in Bentinck Street were acquired. His advice in the selection of the property and his help in planning the rehousing of the Society's Library were invaluable.
>
> "By Mr. Lyle's death the Council has lost a devoted member and the Honorary Officers a much valued friend."

STANLEY JEVONS

Professor Stanley Jevons who died on June 27th, 1955, at the age of 79 after a sudden illness was, like his father before him, one of that relatively rare breed of scientist turned economist. The death of this, lovable, human, though somewhat retiring character, will be sincerely regretted by academic colleagues in British Universities, in Australia and in Burma, as well as by the Ethiopian nation whose friend and helper he had been for nearly twenty years. Possessed of a quiet voice and gentle manner he was a charming conversationalist though never an effective platform speaker or public orator. He inherited his dislike of the platform from his father, who wrote on his retirement from his academic chair at University College, London, at the relatively early age of 45, "for years past I have never entered a lecture room without a feeling probably like that of going to the pillory". Jevons felt deeply on all human questions and would pursue with relentless vigour those he deemed responsible for wrongs which should be put right. A champion of Welsh housing reform in his early years his last days were spent on planning a book on "A Socialist programme for a Labour Government."

Herbert Stanley Jevons was born on October 8th, 1875, the son of the illustrious William Stanley Jevons, economist and logician, and grandson of Thomas Stanley Jevons of Liverpool, a wealthy iron merchant, and a friend of Stephenson, much interested in the engineering innovations of the age. Herbert Jevons was barely seven when his father died at the early age of 47, having in those short years produced not only his well-known book on the Coal question but also his *Theory of Political Economy* and his *Principles of Science*. With such a background it is

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not surprising that his son when he left Giggleswick school in Yorkshire to attend University College, London, had already made up his mind to follow in his father's footsteps. He afterwards went to Trinity College, Cambridge, and after a period in the Geological Institute of Heidelberg returned for a time to Cambridge as demonstrator in Petrology.

For the next two years he lectured in geology and mineralogy at Sidney University and on completing his term was appointed lecturer in economics and political science at Cardiff University College, succeeding shortly after to the Fulton chair there in those subjects.

Jevons's long association with India began in 1914 when he was appointed to the Chair of Economics in the University of Allahabad, which he held until 1923. For most of this time he was also editor of the *Indian Journal of Economics*. In 1923 he was elected to the Chair of Economics in the University of Rangoon. During his period there Jevons made a special study of the economic problems of the Indian cotton industry on the practical as well as on the theoretical side. The knowledge he acquired helped him to start a scheme which brought about a substantial expansion of mutual trading between the manufacturers and merchants of India and Lancashire.

On his return to England in 1930 he wrote and lectured extensively and began to take a more direct and active interest in the affairs of the Society. He had been elected a Fellow of the Society as far back as November, 1907. He became a member of the Council in the year 1932–33 and again in 1936–37. In 1933 he read a paper before the Society on "The Causes of Fluctuations of Industrial Activity". He also took part in discussions on subsequent papers on this and allied subjects right up until 1953, undeterred by increasing uncertainty of health.

After Mussolini had attacked Ethiopia in October, 1935, Jevons founded the Abyssinia Association to express Britain's sympathy with the Ethiopian cause and to assist the Emperor Haile Selassie in his efforts to regain his Kingdom. Throughout the period of the Emperor's exile Jevons was honorary Secretary of the Association and treasurer until 1951. He was also treasurer of the Anglo-Ethiopian Society from 1952–1954. He became a close friend of the Emperor, accompanying him to Geneva when he went to plead his country's case before the League of Nations. His interest in Ethiopia did not end with the restoration of the Negus to his throne, and from 1942 until his death he was British Adviser to the Ethiopian Embassy in London.

Like his father, Jevons wrote much better than he spoke. In addition to editing his father's book *The Theory of Political Economy*, he produced several books of his own reflecting his own particular individuality. This was specially evident in his own work on the British Coal Trade published in 1915. This combined a grasp of the geology of the Coal fields with a thorough understanding of its intricate economic issues. His two volumes on Indian Currency, Banking and Exchange incorporated the results of the researches he had made while in India and Burma. He also published a book on the *Economics of Tenancy Law and Estate Management* together with numerous articles on petrology, mineralogy and political economy. His last published work *Economic Equality in the Co-operative Commonwealth* revealed both his idealism and his longing in the words of his distinguished father "to become a powerful good in the world".

George Findlay Shirras

George Findlay Shirras, an honorary Fellow of the Society, died on June 23rd, 1955, in the aircraft which was taking to Rio de Janeiro the participants at the 29th session of the International Statistical Institute. Professor Shirras was born in Aberdeen on July 16th, 1885, and was thus within a few weeks of his 70th birthday. Although most of his active life was spent in India he was well known in statistical circles in London owing to his frequent visits to the United Kingdom.

In 1909, at the age of 24, he was appointed Professor of Economics at Dacca College, India, and from then to 1939 he held a succession of appointments in that country. From 1910 to 1913 he was attached to the Finance Department of the Government of India and in 1914 was appointed to the newly created post of Director of Statistics, which he held until 1921. In this capacity he attended the British Empire Statistical Conference in London in 1919–1920, and also in virtue of this position was elected an honorary Fellow of the Society in May, 1920. (He had been a Fellow of the Society since 1911.)

In 1920–1921 he was attached to the India Office, in connection with India's claim to be one of the "eight states of chief industrial importance" which were entitled, under the Treaty of Versailles, to non-elective seats on the Governing Body of the International Labour Office. The original list, drawn up in 1919, did not include India, which thereupon submitted a protest to the competent body, the Council of the League of Nations. The Statistical Memoranda, compiled by Shirras convinced the Council of the justice of India's claim and she was included in the list in 1922, a position she has held ever since.

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In 1921 the Bombay Government set up a Labour Office and Shirras was appointed Director. During the five years he held this office he was responsible for a number of pioneer studies on labour questions, and his reports on working-class budgets, and on wages of cotton-mill workers and agricultural workers are well known to students of these subjects. He also compiled the first series of cost of living index numbers. In 1926 he became Professor of Economics at Gujurat College, University of Bombay, a post he occupied until 1939 when he returned to the United Kingdom. From 1940 to 1945 he was Professor of Economics at the University of Exeter and in 1946 he was for a short time Controller-General of Public Revenue and Finance in the Control Commission for Germany (British Element). In the last few years of his life he held various academic appointments as visiting professor in Dublin, Cornell, Illinois and Harvard Universities.

Shirras contributed three papers to the proceedings of the Society. The first, in June 1920, was on "Some Effects of War on Gold and Silver"; the second, in June 1925, was on "Taxable Capacity and the Burden of Taxation and Public Debt"; and the third, in June 1943, on "Methods of estimating the Burden of Taxation". Each of these papers gave rise to a valuable discussion in which many distinguished Fellows of the Society took part. In 1919 appeared his volume on *Indian Finance and Currency*; and in 1924, his two volumes on *The Science of Public Finance*; In collaboration with Dr. Rostas, at the request of the National Institute of Economic and Social Research, he undertook an inquiry in 1943 "to estimate how much was paid in taxation out of each of a number of different incomes in the pre-armament year 1937–38 and in a recent year 1941–42". The results were published in a volume entitled *The Burden of British Taxation*. The methods adopted in this inquiry formed the subject of the paper read to the Society in 1943 as mentioned above. In 1944 he published his book on *Federal Finance in Peace and War*.

His many acquaintances in this country and abroad (he was elected a member of the International Statistical Institute in 1924 and attended many of its sessions) will remember his remarkable personality and abounding energy. In January, 1952, the last occasion on which the writer of these lines met him—at the International Statistical Conferences in Calcutta—he was full of vitality and said he was engaged on a life of Isaac Newton—a project which will now never be carried out by him.

J. W. Nixon.

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Statistical and Economic Articles in Recent Periodicals

United Kingdom—

Accounting Research—

July 1955—Depreciation in published company reports: *L. Goldberg.* The measure of income for shareholders and for taxation: *S. J. Prais.* Transaction models with an example based on the British national accounts: *R. Stone.* The measurement of profits—a study in methods: *R. K. Nigam.* Accounting dynamics—III: *F. Sewell Bray.*

British Journal of Statistical Psychology—

May 1955—A study of the performance of 2,000 children on four vocabulary tests: *J. A. Roberts* and *M. I. Dunsdon.* An additive metric from all the principal components of a perfect scale: *L. Guttman.* The correlation between variate values and ranks: *A. Stuart.* A psychological study of typography: *C. Burt, W. F. Cooper* and *J. L. Martin.*

Faculty of Actuaries, Transactions—

Vol. 23, Part 2, No. 187—The profitability of group pension business: *A. C. Stalker.* Phillips Committee on the economic and financial problems of the provision for old age—statistics of privately administered schemes.

Incorporated Statistician—

July 1955—Retail trade statistics: *W. Rudoe.* Some sampling problems in agriculture: *H. Palca.* Health statistics: *E. Huppert.*

Institute of Actuaries Students' Society, Journal—

July 1955—Some statistical aspects of non-life insurance: *R. E. Beard.* Operational research: *R. T. Eddison.*

Journal of Agricultural Economics—

June 1955—The competitive position of British agriculture: *E. F. Nash.* The economics of the commercial egg production industry of the United Kingdom: *D. H. Lloyd.* The agricultural expansion programme, 1947–51: *E. H. Whetham.* Labour productivity in British agriculture: *M. C. Mathieson.* Pig costing: *J. Clark.*

Oxford Economic Papers (New Series)—

June 1955—The place of the economist in government: *Sir R. Hall.* The terms of trade and the national income, 1950–52: *J. R. Parkinson.*

Oxford University Institute of Statistics, Bulletin—

May 1955—Incomes, savings and net worth: the savings surveys of 1952–1954: *T. P. Hill.* Patterns of savings: the surveys of 1953 and 1954: *L. R. Klein.* The means of subsistence: income from earnings and from assistance, 1935–53: *T. Schulz.* A "human needs" diet: spring 1955: *T. Schulz.*

Population Studies—

July 1955—An examination of generation fertility in England and Wales: *N. H. Carrier.* A century of international mortality trends: *G. J. Stolnitz.* Marshall on the population problem, pt. 2: *J. J. Spengler.* Variations in mortality and life expectations: *C. E. V. Leser.* The formal theory of social mobility: *S. J. Prais.* The concept of statistical freedom and its application to social mobility: *A. Gabor.* Some remarks on the measurement of social mobility: *W. Z. Billewicz.* Appendix note on a statistical question raised in the preceding paper: *J. Durbin.* Some remarks on the measurement of social mobility—a reply: *W. Scott.*

Review of Economic Studies—

Vol. XXII (3), No. 59—On choosing between probability distributions: *A. D. Roy.* Costs in alternative locations: the radio industry: *D. C. Hague* and *J. H. Dunning.*

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EIRE—

Journal of the Statistical and Social Inquiry Society of Ireland—

One Hundredth and Seventh Session 1953–54, Vol. XX—The social geography of Belfast: *E. Jones.* An analysis of Irish transport acts, etc.: *B. F. Shields.* A study of factors which determine the supply of pigs: *R. O'Connor.* Ireland's future in the world demand on energy resources: *D. T. Flood.* Symposium on the economic outlook for 1954: *C. F. Carter and others.* Some aspects of production costs in Irish agriculture, as illustrated by the cost of producing sugar beet: *M. J. Costello.* Some precursors of Bord na Móna: *C. S. Andrews.*

AUSTRALIA AND NEW ZEALAND—

Economic Record—

May 1955—Population growth and levels of consumption in New Zealand: *H. Belshaw.* The aggregate supply of New Zealand farm products: *R. W. M. Johnson.* The impact of electricity: *E. A. Boehm.*

INDIA—

Sankhyā—

March 1955—Market price versus factor cost in national income statistics: *R. Frisch.* A method of discrimination in time series analysis—I: *A. Rudra.* The National Sample Survey Number 6. Relative efficiency of gauging and exact measurement in estimating the proportion of a population between given limits: *D. Raj.* Scaling procedures in scholastic and vocational tests: *P. K. Bose* and *S. B. Choudhury.* On the evaluation of gross value in agriculture by making use of district-wise price data and the state outturn: *M. Mukherjee.* A possible use of certain measurements in control by gauging: *B. C. Bhattacharyya.* A note on some physical measurements of the students of the senior-intermediate class of the Annamalai University in the year 1947–48 : *G. Sankaranarayanan.* A suggestion to make statistics a complete sitting job: *F. Schafer.*

UNION OF SOUTH AFRICA—

South African Journal of Economics—

June 1955—Economic aspects of the Karakul industry in South West Africa: *D. C. Krogh.* The rise of the African tobacco industry in Nyasaland and its production problems: *E. W. Haviland.*

UNITED STATES—

American Economic Review—

June 1955—Obsolescence and technological change: *M. Frankel.*

American Statistical Association, Journal—

June 1955—A review of the statistical evidence on the association between smoking and lung cancer: *S. J. Cutler.* Non-white population increases in metropolitan areas: *P. F. Coe.* The prospect for population forecasts: *J. Hajnal.* A technique for estimating the population of counties: *H. H. Brown.* The memory factor in social surveys: *P. G. Gray.* Measuring the error of editing the questionnaires in a Census: *S. Nordbotten.* The relationship of housing prices and building costs in Los Angeles: *R. M. Williams.* A test of a linear function of the deviations between observed and expected numbers: *W. G. Cochran.* The estimation of an optimum subsampling number: *S. H. Brooks.* Extended tables for use with the "*G*" tests for means: *J. E. Jackson* and *E. L. Ross.* The properties of the mean square successive difference in samples from various populations: *P. G. Moore.* Sampling plans for inspection by variables: *G. J. Lieberman* and *G. J. Resnikoff.* Practical applications of the theory of extreme values: *B. F. Kimball.* Estimate of the integrated normal curve by minimum normit chi-square with particular reference to bio-assay: *J. Berkson.* Numerical analysis research unpublished statistical tables: *D. Teichroew.* A refinement in the use of mark-sense cards for test research: *V. Appel* and *G. Cooper.*

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Annals of Mathematical Statistics—

June 1955—On tests of normality and other tests of goodness of fit based on distance methods: *M. Kac, J. Kiefer* and *J. Wolfowitz*. Some classes of partially balanced designs: *R. C. Bose* and *W. H. Clatworthy*. The distribution of length and components of the sum of *n* random unit vectors: *J. A. Greenwood* and *D. Durand*. On the efficiency of experimental designs: *S. Ehrenfeld*. On the approximation of a distribution function by an empiric distribution: *J. Blackman*. The extrema of the expected value of a function of independent random variables: *W. Hoeffding*. Estimates of bounded relative error in particle counting: *M. A. Girschick, H. Rubin* and *R. Sitgreaves*. A characterization of sufficiency: *R. R. Bahadur*. Distribution of the maximum of the arithmetic mean of correlated random variables: *J. Gurland*. Significance probabilities of the Wilcoxon test: *E. Fix* and *J. L. Hodges, Jr*. On the Fourier series expansion of random functions: *T. S. Pitcher*. A characterization of the gamma distribution: *E. Lukacs*. The ratio of variances in a variance components model: *W. A. Thompson, Jr*. On moments of order statistics from the Weibull distribution: *J. Lieblein*. On the asymptotic normality of some statistics used in nonparametric tests: *M. Dwass*. Empirical power functions for nonparametric two-sample tests for small samples: *D. Teichroew*. A note on the theory of unbiassed estimation: *D. Basu*. On confidence intervals of given length for the mean of a normal distribution with unknown variance: *L. Weiss*.

Biometrics—

June 1955—Rules of thumb for determining expectations of mean squares in analysis of variance: *E. F. Schultz, Jr*. Variance components with reference to genetic population: *D. C. Lowry*. Fitting the Neyman type A (two parameter) contagious distribution: *J. B. Douglas*. Use of the simplex design in the study of joint action of related hormones *P. J. Claringbold*. Statistical analysis of multiple slope ratio assays: *C. G. Barraclough*. An analysis of perennial crop data: *R. G. D. Steel*. An introductory course in biometry for graduate students in biology: *C. I. Bliss*. The theory of bacterial constant growth apparatus: *C. C. Spicer*. An inverted matrix approach for determining crop-weather regression equations: *H. F. Huddleston*.

Econometrica—

July 1955—Income distributions: a new model: *R. S. G. Rutherford*. Optimal solution of a dynamic Leontief model with substitution: *G. B. Dantzig*. Sur l'importance en économétrie de la distinction entre les probabilités rationnelles et irrationnelles: *M. Fréchet*. A model for optimizing production by reference to cost surrogates: *A. Charnes, W. W. Cooper* and *B. Mellon*.

Estadística—

June 1955—La fuerza de trabajo de México: un análisis de su estructura, sus caracteristicas y su evolutión: *E. U. Romo*. Lung cancer in the twentieth century: *H. L. Dunn*. Concepts and methods used in the current labor force statistics prepared by the U.S. Bureau of the Census (1945): *U.S. Bureau of the Census*.

Industrial Quality Control—

June 1955—Application of consolidated computer to the solution of a metallurgical regression problem: *D. S. Leckie* and *R. F. Cain*. Chi square tests of independence and the comparison of percentages: *A. J. Duncan*. The challenge of SQC in manufacturing plastics raw materials: *H. L. Wehrly*. Acceptance sampling: *D. J. Blackwell*. Simplifying quality control operations with marginal punched cards: *B. Giffler*. Some applications of Hotelling's T: *C. R. Hicks*.

August 1955—Department store uses of statistical quality control: *C. S. Brinegar*. Some applications of quality control techniques to clerical work: *R. B. Selover*. What ASQC has done for quality control: *P. A. Robert*. The technique of regression analysis: *B. B. Day, F. R. Del Priore* and *E. Sax*. Statistical control in continuous chemical processing: *R. M. Hofstead* and *H. W. Isleib*. Some applications of quality control techniques in motor oil can filling: *V. Filimon, R. Maggass, D. Frazier* and *A. Klingel*. Planning and operating a receiving inspection department: *A. R. Jackson*.

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Journal of Political Economy—

June 1955—Economic development, income distribution, and capital formation in Mexico: *A. Sturmthal.* Sterling's recurring postwar payments crises: *S. I. Katz.* Recent developments in cost accounting and the "marginal analysis": *J. S. Earley.* Location theory and regional economic growth: *D. C. North.*

Mathematical Tables and Other Aids to Computation—

April 1955—A method for finding roots of arbitrary matrices: *J. Greenstadt.* Double interpolation formulae and partial derivatives in terms of finite differences: *K. C. Ho.*

Milbank Memorial Fund Quarterly—

July 1955—A short-term longitudinal morbidity investigation: *J. R. Smiley, C. Buck* and *G. E. Hobbs.* Some demographic measurements for Egypt based on the stability of census age distribution: *M. A. El-Badry.*

Monthly Labor Review—

June 1955—A review of automatic technology.

Psychometrika—

June 1955—Estimation and tests of significance in factor analysis: *C. R. Rao.* Reliability formulas for noncompleted or speeded tests: *L. Guttman.* A mathematical model for conditioning: *G. W. Boguslavsky.* Two models of group behavior in the solution of eureka-type problems: *I. Lorge* and *H. Solomon.* On the design of automata and the interpretation of cerebral behavior: *S. Frankel.*

Society of Actuaries, Transactions—

August 1955—A practical method of forecasting a life insurance company's gross operating earnings for the current year: *J. Barrett Walker.* Mortality experience of Union Civil War veterans: *R. J. Myers* and *L. O. Shudde.*

BELGIUM—

Bulletin de l'Institut de Recherches Économiques et Sociales—

August 1955—La formation des tarifs des chemins de fer belges de 1927 à 1939: *E. Nolet de Brauwere.* La formation des prix du chemin de fer de Matadi à Léopoldville 1898–1954: *A. Huybrechts.*

BRAZIL—

Revista Brasileira de Estatística—

January–March 1955—Evolução da população Norte-Americana: *R. Freire.* Nota sôbre o cálculo das migrações interiores baseado nos censos: *G. Mortara.*

FRANCE—

Journal de la Société de Statistique de Paris—

January–March 1955—L'importance de la notion de valeur en statistique. Applications à l'évaluation de la production minière mondiale: *E. Ventura.* Relations entre la composition des familles et le taux de masculinité: *E. Malinvaud.*

Revue de Statistique Appliquée—

Vol. III, No. 2—Principes fondamentaux de la méthode statistique et applications industrielles (2e partie): *J. Mothes.* Le contrôle des traitements thermiques des pièces par les méthodes statistiques: *P. Pommier, G. Brunel* and *J. Calliez.* Gestion des stocks: *R. Hénon.* Irregularité de remplissage dans le paquetage mécanique: *B. Cyffers.* Utilisation des fiches perforées à 80 colonnes pour l'interprétation des résultats des expériences factorielles: *M. Ollagnier* and *D. Gros.* Les méthodes d'analyse de la variance: *E. Morice.* Estimation d'une relation structurale et comparaison de deux méthodes de mesure d'une même grandeur: *F. Bastenaire.* La recherche opérationnelle: *A. Leroy.* Introduction à l'étude des programmes linéaires: *E. Malinvaud.*

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HOLLAND—

Statistica—

Vol. 8, No. 3–4—Grafiekenpapier: *H. Ferro.* De vervaardiging van een systeem functieponskaarten: *Th. J. D. Erlee.* The effect of rounding-off in samples: *M. E. Wise.* A discussion of the rules for rounding-off as given in the Dutch draft standard *V*1047: *M. E. Wise* and *H. C. Hamaker.* Selectie bij de plantenveredeling op grond van proefveldresultaten: *J. W. Sieben.*

ITALY—

Giornale degli Economisti e Annali di Economia—

March–April 1955—Gradus ad Parnassum: *E. Zaccagnini.* Un esempio di applicazione del metodo del simplesso alla teoria della produzione: *S. Ricossa.* Sulla distribuzione del coefficiente di correlazione parabolica d'ordine *K* calcolato per grandi campioni casuali estratti da un dato universo: *V. Amato.* Gli scarti per differenze e gli scarti per rapporto in relazione ai metodi di quasi aderenza: *L. Vajani.*

Statistica—

April–June 1955—Sulla misura della concordanza tra *m* graduatorie: *V. Amato.* Ulteriori considerazioni sul mercato cinematografico e sul rendimento dei film: *A. Bellettini.*

JAPAN—

Union of Japanese Scientists and Engineers, Reports of Statistical Application Research—

February 1955—Notes on sampling inspection plans: *S. Moriguti.* A problem in the theory of queues: *T. Kawata.* On minimax tests of hypotheses: *M. Sakaguchi.* Minimax approach to a single sample inspection by attributes: *S. Ura.*

SPAIN—

Trabajos de Estadistica—

Vol. V, Part III—Systems of frequency curves derived from the first law of Laplace: *N. L. Johnson.* Sobre la independencia de variables aleatorias: *P. Zoroa.* Sobrevisión por muestro en Universidades Españolas: *F. Azorin.* Notas para la enseñanza de algunos conceptos elementales de estadística en la Bachillerato: *S. Ferrer.*

INTERNATIONAL—

International Labour Review—

April 1955—International comparisons of wage structures: *T. Dunlop* and *M. Rothbaum.* The contribution of life insurance to social security in the United States: *C. C. Nash.*

Productivity Measurement Review—

May 1955 (No. 1)—Input-output analysis as a basis for productivity measurement: *K. Borch.* Methods of productivity measurement in the nationalised basic industries in Austria: *R. Grünwald.*

Revue de l'Institut International de Statistique—

Vol. 22, No. 1–3—The grouping of observations in regression analysis: *S. J. Prais* and *J. Aitchison.* Errors in variables: *J. Durbin.* Recherche d'une fonction de coût applicable aux enquêtes par sondage de l'Institut National de la Statistique et des Études Économiques: *P. Thionet.* The ASN concept in attributes double sampling plans: *A. Abruzzi.* Comparability of statistics of capital formation: *J. B. D. Derksen.* A survey of the living conditions of Arab families in Tripolitania in November–December 1950: *J. L. Nicholson.* The Social survey of Port Louis (Mauritius): *L. Silberman.*

United Nations, Populations Bulletin—

December 1954—Gaps in existing knowledge of the relationships between population trends and economic and social conditions. (Report of a Committee of Experts appointed by the Secretary-General of the United Nations.) Fertility according to size of family: application to Australia: *L. Henry.* Differential fertility in Ceylon: *E. Huyck.* The cause of the ageing of populations: declining mortality or declining fertility? (Article prepared by the Population Division of the United Nations.)

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LIST OF ADDITIONS TO THE LIBRARY

Since the issue of Part III, 1955, the Society has received the publications enumerated below:

I.—OFFICIAL PUBLICATIONS

United Kingdom. *Air Ministry.* Report on the health of the Royal Air Force and Women's Royal Air Force for the year 1951. [Air Ministry, 1955.] 71p. 13″. [The first post war annual health report of the Royal Air Force to be released for open publication.]

Board of Trade. Report of the United Kingdom trade mission to Egypt, the Sudan and Ethiopia: February, 1955. London, H.M.S.O., 1955. 175p. fold. map. 9½″. 6*s.*

Colonial Office. African consumers in Nyasaland and Tanganyika: an enquiry into the distribution and consumption of commodities among Africans carried out in 1952–1953; by Fergus Chalmers Wright. London, H.M.S.O., 1955. 117p. fold. map. 9¾″. 12*s.* 6*d.* (Col. Res. Stud. 17.)

Committee on Crown Lands. Report of the Committee on crown lands. London, H.M.S.O., 1955. 28p. 9¾″. 1*s.* Cmd. 9483.

Commonwealth Economic Committee. Canned food: a summary of figures of production, consumption and trade relating to the principal canned foods. London, H.M.S.O., 1955. v, 98p. 9¾″. 5*s.*

General Register Office. Census 1951. England and Wales: populations of ecclesiastical areas (England). London, H.M.S.O., 1955. viii, 185p. 13″. 35*s.*

Census 1951. Wales (including Monmouthshire): report on Welsh speaking population. London, H.M.S.O., 1955. xvi, 32p. maps. 13″. 7*s.* 6*d.*

Ministry of Health. An outbreak of food poisoning due to *salmonella bovis morbificans* (Basenau) in which the vehicle of infection was meat pies; report by A. A. Miller, C. G. M. Nicol, and F. Ramsden. London, H.M.S.O., 1955. iv, 54p. 4 plates. 9¾″. 2*s.* 6*d.* (Rep. Publ. Hlth. Med. Subj. No. 96.)

Report of the working party set up to devise a system of costing the departments and services of a hospital. London, H.M.S.O., 1955. 52p. 9¾″. 2*s.*

Home Office. Prediction methods in relation to Borstal training; by Hermann Mannheim, and Leslie T. Wilkins ... London, H.M.S.O., 1955. viii, 276p. 9½″. 17*s.* 6*d.* (Home Office Studies in the causes of delinquency and the treatment of offenders I.)

Iron and Steel Board. Annual report for the period 13th July, 1953, to 31st December, 1954. London, H.M.S.O., 1955. iv, 35p. 9¾″. 1*s.* 3*d.*

Medical Research Council. Psychological tests for accident proneness and industrial proficiency; a summary of Reports Nos. 38, 55, 68, 74 and 84 of the Industrial Health Research Board; [by] E. G. Chambers. London, H.M.S.O., 1955. iv, 29p. 9½″. 2*s.* (M.R.C. Memorandum No. 31.)

The Rh blood groups and their clinical effects; by P. L. Mollison, A. E. Mourant and R. R. Race. 3rd edition. London, H.M.S.O., 1954. vi, 73p. 9½″. 3*s.* (M.R.C. Memorandum No. 27. 2nd ed. 2nd revision of Memorandum No. 19.)

Studies on expenditure of energy and consumption of food by miners and clerks, Fife, Scotland, 1952; R. C. Garry, R. Passmore, Grace M. Warnock and J. V. G. A. Durnin. London, H.M.S.O., 1955. vi, 69p. 1 plate, diagrs. 9½″. 5*s.* (M.R.C. Spec. Rep. Ser. No. 289.)

Medical Research Council. Rheumatic Fever Working Party. Treatment of acute rheumatic fever in children: a co-operative clinical trial of A.C.T.H., cortisone, and aspirin; a joint report by the Rheumatic Fever Working Party ... and the Subcommittee of principal investigators of the American Council on Rheumatic Fever and Congenital Heart Disease, American Heart Association. *Brit. Med. J.* (1955), **1**, 555–574. 20p. 11″. Published simultaneously in *Brit. Med. J.* and *Circulation.*

Monopolies and Restrictive Practices Commission. Collective discrimination: a report on exclusive dealing, collective boycotts, aggregated rebates and other discriminatory trade practices. London, H.M.S.O., 1955. iv, 111p. 9¾″. 3*s.* 6*d.* Cmd. 9504.

National Physical Laboratory. Handbook for computers; by Sylvia W. Skan. [London,] Department of Scientific and Industrial Research, 1954. 2v. 12¾″. 15*s.*

Scotland. Department of Health. Rents of houses owned by local authorities in Scotland, 1954. Edinburgh, H.M.S.O., 1955. 42p. 9¾″. 2*s.* Cmd. 9539.

Scottish Education Department. Public education in Scotland. Edinburgh, H.M.S.O., 1955. 58p. 8½″. 2*s.*

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Argentina. *Direccion Nacional del Servicio Estadistico.* IV censo general de la nacion [1947.] Tomo II. Censo agropecuario. Buenos Aires, [1955.] xxiv, 491p. 10½″.

Australia. *Bureau of Agricultural Economics.* An economic survey of a sample of commercial egg producers, 1953–54. Canberra, [1955.] 12p. 11″. Reprinted from *The Poultry Farmer*, June 11, 1955.

Cordoba (Argentina). *Direccion General de Estadistica, Censos e Investigaciones.* Sintesis estadistica del trienio 1949–1951. Cordoba. [x,] 202p. 12 fold tables. 10½″.

Cyprus. Economic survey 1954. Nicosia, Government Printing Office, 1955. 31p. 9¾″. 150 *mils.*

Egypt. *Ministry of Finance and Economy. Statistical Department.* Industrial and commercial census 1947 Cairo, 1955, [v.] 783p. 13½″. *pt.* 200. In English and Egyptian.

France. *Institut National de la Statistique et des Etudes Economiques.* Les comptabilités nationales dans le monde: comparaison des méthodes. Paris, Presses Universitaires de France, 1952. 256p. fold. tab. 10½″. *Etudes et Conjoncture* 1952, numéro spécial hors série.

Recensement de 1954: population des départements d'outre-mer. Paris, 1954. 12p. 10¾″.

Frankfurt am Main. *Statistisches Amt.* Das Sozialprodukt der Stadt Frankfurt am Main 1950–1953; von Dr. Rudolf Gunzert. Frankfurt, 1955. 50p. 11¾″. (Statistische Monatsberichte Sonderheft 3.)

Hague, The. *Gemeentelijk Bureau voor Statistiek.* Het Haagse prijsindexcijfer van het levensonderhoud. 'S-Gravenhage, the Bureau, [1955.] 19p. 9¾″.

India. *Office of the Registrar General.* Census of India, 1951. Volume I. India. Part I–B. Appendices to the census report, 1951. Delhi, Manager of Publications, 1955. [viii,] 419p. 11″. 5*s.*

Subsidiary tables, 1951 census. 1954. ii, 270p. 10¾″. 4*s.* (Census of India Paper 7.)

Israel. *Central Bureau of Statistics and* **Falk Project for Economic Research in Israel.** Provisional estimates of Israel's national income, 1952–1953; by Daniel Creamer. Jerusalem, 1955. [36p.] 12½″. 600 *prutah.* (Special Series 29.)

Italy. *Istituto Centrale di Statistica.* Elezione della Camera dei Deputati, 7 giugno 1953. Volume 1. Legislazione elettorale–certificati–elettori–votanti–risultati per comune desunti dai verbali elettorali di sezione. Roma, 1955. 397p. 10½″. *L.*1500.

Japan. *Bureau of Statistics.* Population census of 1950. Vol. 5. All Japan. 2. Labor force status, occupation, industry, class of worker. [Tokyo, 1955.] [iv,] 591p. 10″.

Karinthia. *Amt der Kärntner Landesregierung.* Wirtschaftsbericht für Kärnten, 1953 und 1954. Klagenfurt, 1954–5. 2v. 11½″.

New Zealand. *Census and Statistics Department.* Census of public libraries, 1954. Wellington, 1955. 16p. 12¼″.

Norway. *Statistisk Sentralbyrå.* Økonomisk utsyn 1900–1950. Economic survey 1900–1950. Oslo, Statistisk Sentalbyrå, 1955. 217p. 9½″. (Samfunnsøkonomiske Studier 3.)

Portugal. *Instituto Nacional de Estatistica.* Fundamentos e objectivos do Plano de Fomento Agrário; pelo engenheiro agrónomo Mário Pereira. Lisboa, 1955. 101p. 9 plates. 9″. $40. (Publicações do Centro de Estudos Económicos.)

Inquérito ao custo de vida na cidade do Porto, 1950–1951. [Lisboa, Instituto Nacional de Estatística.] 1955. 146p. 2 fold. tables. 10½″. $30.00. (Estudos No. 27.)

Southern Rhodesia. [Census of Industrial production, 1938–1953.] Thirteenth report ... covering: (i) Manufacturing, (ii) Construction, (iii) Water and light. Salisbury, Southern Rhodesia, Central African Statistical Office, 1955. [x,] 60p. 13″. 1*s.*

Stockholm. *Stads Statistiska Kontor.* Stockholms Stads Statistiska Kontor femtio år: några data upptecknade av Ivar Öman. Statistical Office of the city of Stockholm 1905–1955, with a summary in English. Stockholm, 1955. 44p. illus. 9½″.

Sweden. *Statistiska Centralbyrån.* Historisk statistik för Sverige. Historical statistics of Sweden. I. Befolkning. Population. 1720–1950. Stockholm, 1955. 78p. 15 diagrs. 9½″. Summary and headings in English.

Switzerland. *Eidgenössisches Statistisches Amt.* Eidgenössisches Volkszählung 1. Dezember 1950. 3. Kantone Appenzell Ausser-Rhoden und Appenzell Inner-Rhoden. 200p. 7. Canton de Genève. 197p. 11. Canton de Neuchâtel. 185p. Bern, 1955. 11¾″. (Statistische Quellenwerke der Schweiz, 270, 273, 266.)

United Nations. *Bureau of Social Affairs. Population Division.* Future population estimates by sex and age. Report II. The population of South America 1950–1980. New York, U.N., 1955. London, H.M.S.O. vi, 139p. map. 10¾″. 9*s.* (Population Studies, No. 21.)

Department of Economic and Social Affairs. Foreign capital in Latin America. New York, U.N., 1955. London, H.M.S.O. viii, 164p. 11″. 12*s.* 6*d.*

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Educational, Social and Cultural Organization. The social sciences. Paris, U.N.E.S.C.O., 1955. London, H.M.S.O. 64p. 8½″. 1*s.* 6*d.* (Unesco and its programme 12.)

Food and Agriculture Organization. Problems of food and agricultural expansion in the Near East. Rome, F.A.O., 1955. London, H.M.S.O. [iv,] 53p. 9″. 2*s.* 6*d.*

Report of the third regional meeting on food and agricultural programs and outlook in Latin America, Buenos Aires, 1–10 September 1954. Rome, F.A.O., 1955. London, H.M.S.O. [iv,] 99p. 9″. 5*s.*

General Agreement on Tariffs and Trade. International trade 1954. Geneva, the contracting parties to the G.A.T.T., 1955. [iv,] 169p. 9½″. $1.50. Third Annual report.

Statistical Office. World weights and measures: handbook for statisticians. Provisional edition; prepared by the Statistical Office of the United Nations in collaboration with the Food and Agriculture Organization ... New York, F.A.O., 1955. London, H.M.S.O. iii, 225p. map. 10¾″. 15*s.* (Statistical Papers, Series M, No 21.)

World Health Organization. Expert Committee on drugs liable to produce addiction. Fifth report. Geneva, W.H.O., 1955. London, H.M.S.O. 16p. 9½″ 1*s.* 9*d.* (World Health Organization Technical Report Series 95.)

Vienna. *Statistisches Amt.* Die Entwicklung des Fremdenverkehrs in Wien nach dem zweiten Weltkrieg. Wien, Magistrat der Stadt, [1955.] 19p. 11¾″. (Mitteilungen aus Statistik und Verwaltung der Stadt Wien, 1955, Sonderheft 3.)

Die Gemeinderats- und Bezirksvertretungswahlen in Wien vom 17. Oktober 1954. Wien, Magistrat der Stadt, [1955.] 40p. 11¾″. (Mitteilungen aus Statistik und Verwaltung der Stadt Wien, 1955, Sonderheft 1.)

Die Wiener Gemeindewohnungen und ihre Bewohner. Wien, Magistrat der Stadt, [1955.] 48p. 11¾″. (Mitteilungen aus Statistik und Verwaltung der Stadt Wien, 1955, Sonderheft 2.)

West Bengal. *State Statistical Bureau.* Report of the comparative costs of living in the different towns of West Bengal during November 1950. Alipore, West Bengal Government Press, 1955. 28p. 13¼″.

Yugoslavia. *Federal Statistical Office.* [Population census of March 15th, 1948] Final results ... Vol. VI. Population by birthplace. xlviii, 95p. Vol. IX. Population by ethnic nationality. xliv, 494p. Beograd, 1955. 11½″. Serbo-Croat, with summaries in French and English.

Statistical pocket-book of Yugoslavia 1955. Beograd, 1955. port. maps. 4¾″.

II.—AUTHORS AND MISCELLANEOUS

Abbot, C. G. Periodic solar variation. Washington, Smithsonian Institution, 1955. 20p. 9½″. (*Smithson. Misc. Coll.* **128**, no. 4.)

Sixty-year weather forecasts. Washington, Smithsonian Institution, 1955. 22p. 9½″. (*Smithson. Misc. Coll.* **128**, no. 3.)

Allen, R. G. D. & Ely, J. Edward, *editors.* International trade statistics. New York, Wiley, 1953. London, Chapman & Hall. xii, 448p. 9″. 54*s.*

Auboin, Roger. The Bank for International Settlements, 1930–1955. Princeton, University, International Finance Section, 1955. 38p. 9″. (Essays in International Finance 22.)

Bahadur, R. R. & Lehmann, E. L. Two comments on "sufficiency and statistical decision functions". *Ann. Math. Statist.* (1955), **26**, 139–142. 10″.

Banca d'Italia. *Servizio Studi Economici.* Contributi all'analisi di alcuni fenomeni trattati nella relazione annuale del Governatore. Roma, Banca d'Italia, 1954. 232p. port. 4 fold. tables. 9½″.

Bash, Wendell H. Differential fertility in Madison County, New York, 1865. *Milbank Mem. Fd. Quart. Bull.* (1955), **33**, 161–186. 9″.

Benham, Frederic. Economics: a general introduction. 5th ed. London, Pitman, 1955. xvi, 568p. 8½″. 18*s.*

Bhattacharjee, Jyoti P. Resource use and productivity in world agriculture. *J. Fm. Econ.* (1955), **37**, 57–71. 9″.

Bonnesen, T. & Fenchel, W. Theorie der konvexen Körper. New York, Chelsea Publishing Co., 1948. viii, 164p. 8½″. 32*s.*

Boole, George. Studies in logic and probability. London, Watts, 1952. 500p. port. 8¾″. 25*s.*

British Iron and Steel Research Association. Conference on works transport, held at Ashorne Hill, Leamington Spa, July 6th and 7th, 1954. Chairman: W. F. Cartwright. London, B.I.S.R.A., 1954. 44p. illus. 11″. 5*s.* Restricted.

British Library of Political and Economic Science. A London bibliography of the social sciences. Vol. IX, 1936–1950, Q–Z. London, B.L.P.E.S., 1955. xii, 960p. 9¾″. 80*s.*

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Buckley, Kenneth. Capital formation in Canada 1896–1930. Toronto, University Press, 1955. London, Cumberlege. x, 163p. 10″. 26*s*. (Canadian Studies in Economics 2.)

Cambridge. University. *Department of Applied Economics.* The British economy—a longer view; by A. A. Adams & W. B. Reddaway. *Times Rev. Ind., Lond. and Camb. Econ. Service Bull.* (1954), No. 12, ii–iv. 6p. 9½″. (Repr. Ser. 90.)

An index of building costs in the United Kingdom, 1845–1938; by K. Maiwald. *Econ. Hist. Rev., Ser.* 2 (1954), **7**, 187–203. 10¼″. (Repr. Ser. 91.)

A synthesis of Engel curve theory; [by] J. Aitchison & J. A. C. Brown. *Rev. Econ. Stud.* (1955), **22**, 35–46. 9¾″. (Repr. Ser. 92.)

Sampling for social accounts—some aspects of the Cambridgeshire survey; by J. E. G. Utting & Dorothy Cole. *Bull. Inst. int. Statist.* (1953), **34**, 30p. 9¼″. (Repr. Ser. 93.)

Misery and bliss: a comparison of the effect of certain forms of saving behaviour on the standard of living of a growing community; [by] Richard Stone. *Econ. int.* (1955), **8**. 24p. 10″. (Repr. Ser. 94.)

The effects of maintained consumption in the unemployed sector; [by] K. Maiwald. *Econ. J.* (1955), **65**, 89–106. 9¾″. (Repr. Ser. 95.)

Cameron, J. M. The use of components of variance in preparing schedules for sampling of baled wool. *Biometrics* (1951), 7, 83–96. 9¼″.

Cameron, J. M. & Ogburn, Fielding. Acceptance sampling of electroplated articles. *Plating* (1954), January. 4p. 11¼″.

Cameron, J. M. & Youden, W. J. The selection of a limited number from many possible conditioning treatments for alloys to achieve best coverage and statistical evaluation. *Proc. Amer. Soc. Test. Mat.* (1950), **50**, 951–964. 9″.

Chung, Kai Lai. Contributions to the theory of Markov chains. *J. Res. Nat. Bur. Stand.* (1953), **50**, 203–208. 10¼″.

Clatworthy, Willard H. A geometrical configuration which is a partially balanced incomplete block design. *Proc. Amer. Math. Soc.* (1954), **5**, 47–55. 9½″.

Partially balanced incomplete block designs with two associate classes and two treatments per block. *J. Res. Nat. Bur. Stand.* (1955), **54**, 177–190. 10¼″.

Cobbett, William. Rural rides in the southern, western and eastern counties of England, together with tours in Scotland and in the northern and midland counties of England, and letters from Ireland; the whole, including many rides and tours never before reprinted, edited . . . by G. D. H. & Margaret Cole. London, Peter Davies, 1930. 3v. illus. maps on endpapers. 10″. A. D. Webb Bequest.

Connor, W. S. Some relations among the blocks of symmetrical group divisible designs. *Ann. Math. Statist.* (1952), **23**, 602–609. 10″.

Connor, W. S. & Clatworthy, Willard H. Some theorems for partially balanced designs. *Ann. Math. Statist.* (1954), **25**, 100–112. 10″.

Cox, D. R. A use of complex probabilities in the theory of stochastic processes. *Proc. Camb. Phil. Soc.* (1955), **51**, 313–319. 10″.

Cox, D. R. & Stuart, A. Some quick sign tests for trend in location and dispersion. *Biometrika* (1955), **42**, 80–95. 11¾″.

David, F. N. & Kendall, M. G. Tables of symmetric functions. Part V. *Biometrika* (1955), **42**, 223–242. 10¾″. 4*s*. (New Statistical Table No. 20.)

Deardorff, Neva R. The religio-cultural background of New York City's population. *Milbank Mem. Fd. Quart. Bull.* (1955), **33**, 152–160. 9″.

Doeblin, Wolfgang. Eléments d'une théorie générale des chaînes simples constantes de Markoff. *Ann. sci. Ec. norm. sup. Paris*, **57**, 61–111. 11″.

Sur certains mouvements aléatoires discontinus. *Skand. AktuarTidskr.* (1939), **22**, 211–222. 9¼″.

Dorsey, N. Ernest & Eisenhart, Churchill. On absolute measurement. *Sci. Mon., N.Y.* (1953), 77, 103–109. 10¼″.

Ehrenberg, A. S. C. Measurement and mathematics in psychology. *Brit. J. Psychol.* (1955), **46**, 20–29. 10″.

Eine Festgabe für Jakob Breuer . . . aus Anlass der Vollendung seines 65. Lebensjahres. Düsseldorf, Statistische Vereinigung, 1955. 99p. 9½″.

Ford, P., Thomas, C. J. & Ashton, E. T. Problem families: the fourth report of the Southampton Survey. Oxford, Blackwell, 1955. xi, 51p. 9½″. 4*s*.

Freeman, G. H. & Hall, Margaret J. Some statistical aspects of a recent series of fruit tree red spider mite control trials. *Ann. Rep. E. Malling. Res. Station* (1954), 102–106. 9¾″.

Gadgil, D. R. Economic policy and development (a collection of writings). Poona, Gokhale Institute of Politics and Economics, 1955. [vi,] 248p. 9¾″. 12*s*. (Publication No. 30.)

CC-0. In Public Domain. Gurukul Kangri Collection, Haridwar

Digitized by Arya Samaj Foundation Chennai and eGangotri

Galenson, Walter. Labor productivity in Soviet and American industry. New York, Columbia University Press, 1955. London, Cumberlege. xiv, 273p. 9″. 45*s*. (Rand research study.)

Grab, Edwin L. & Savage, I. Richard. Tables of the expected value of $1/X$ for positive Bernoulli and Poisson variables. *J. Amer. Statist. Ass.* (1954), **49**, 169–177. 9¼″.

Greaves, Ida. The colonial sterling balances. Princeton, University, International Finance Section, 1954. 21p. 9″. (Essays in International Finance 20.)

Grundy, P. M., Rees, D. H. & Healy, M. J. R. Decision between two alternatives—how many experiments? *Biometrics* (1954), **10**, 317–323. 9¼″.

Hall, Marshall & Connor, W. S. An embedding theorem for balanced incomplete block designs. *Canad. J. Math.* (1953), **6**, 35–41. 9¾″.

Halmos, Paul R. Measure theory. New York & London, Van Nostrand, 1954. ii, 304p. 9″. 47*s*.

Hamaker, H. C. Economic principles in industrial sampling problems: a general introduction. *Bull. Inst. int. Statist.* (1951), **33**, Part V, 105–122. 9¾″.

The efficiency of sequential sampling for attributes. Part I. Theory. Part II. Practical applications. *Philips Res. Rep.* (1953), **8**, 35–46, 427–433. 9″.

The industrial application of statistics in the Netherlands. *Bull. Inst. int. Statist.* (1950), **32**, 2e liv., 76–98. 10″.

Industrial applications of statistics in various countries. *Bull. Inst. int. Statist.* (1951), **33**, Part V, 13–28. 9¾″.

Lot inspection by sampling. *Philips Tech. Rev.* (1949), **11**, 176–182. 7 l. 11¾″.

[Review of] Sampling inspection by variables; by A. H. Bowker and H. P. Goode, 1952. *J. Amer. Statist. Ass.* (1954), **49**, 386–389. 9¼″.

Some notes on lot-by-lot inspection by attributes. *Rev. Inst. int. Statist.* (1950), **18**, 179–196. 10½″. Presented at the 26th Session of the I.S.I., Berne, September, 1949.

Statistics and standardization in various other countries. *Bull. Inst. int. Statist.* (1955), **34**, Part IV, 276–280. 7p. 9½″.

The teaching of statistics to industry in various other countries. *Bull. Inst. int. Statist.* (1954), **34**, Part II, 649–654. 8p. 9½″.

The theory of sampling inspection plans. *Philips Tech. Rev.* (1950), **11**, 260–270. 11 l. 11¾″.

Hamaker, H. C., Chabot, J. J. M. Taudin & Willemze, F. G. The practical application of sampling inspection plans and tables. [*Philips Tech. Rev.* (1950), **11**, 362–372.] 11 l. 11¾″.

Hamaker, H. C., & Strik, R. van. The efficiency of double sampling for attributes. I. Eindhoven, Philips Research Laboratories, [1954.] [32 l.] 11¾″. Typescript.

Heyworth, Sir Geoffrey. Transport. [London,] Unilever, 1955. 15p. 4pl. 8¼″. For private circulation.

The United Africa Group. [London,] Unilever, 1954. [ii,] 20p. map. 8″. For private circulation.

Hicks, Ursula K. British finances: their structure and development, 1880–1952. London, Cumberlege, 1954. 225p. fold. table. 6½″. 6*s*.

Hulton Research. The Hulton readership survey 1955; produced by the British Market Research Bureau Limited for Hulton Research. Ninth year of publication. London, Hulton Press, 1955. 56p. 17½×13¼″.

Hunsaker, J. C. Biographical memoir of Elmer Ambrose Sperry 1860–1930. Washington, National Academy of Sciences, 1955. 40p. port. 9″.

International Association for Research in Income and Wealth. Income and Wealth. Series IV. Papers by Ragnar Frisch, Richard Stone, D. B. J. Schouten, J. Lips, Milton Gilbert, Irving B. Kravis, D. Paige, S. Adler, J. L. Nicholson, Jan Marczewski, E. F. Jackson, G. Stuvel, Raymond Goldsmith; edited by Milton Gilbert and Richard Stone. London, Bowes & Bowes, 1955. xii, 388p. 8½″. 42*s*.

International Federation of Cotton and Allied Textile Industries. The cotton industry today and tomorrow: official report on the Jubilee International Cotton Congress held at Buxton, England, 13th–20th May 1954; edited by Mario Ludwig. Manchester, International Federation of Cotton and Allied Textile Industries, [1955.] 288p. fold. pl. illus. 9½″.

International Statistical Institute. Summaries of lectures delivered at the Statistical Seminar held at Rome, September 1953. The Hague, 1955. viii, 121p. 11½″.

Iron and Steel Industrial Research Council. Statistical methods in industry: a course of six lectures given in Sheffield by Mr. L. H. C. Tippett ... British Iron and Steel Federation, 1943. 74p. 9¼″.

Kendall, D. G. Bernstein polynomials and semigroups of operators. *Math. Scand.* (1954), **2**, 185–186. 9½″.

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Digitized by Arya Samaj Foundation Chennai and eGangotri

[Review of] Introduction to the theory of stochastic processes depending on a continuous parameter. By H. B. Mann. *Bull. Amer. Math. Soc.* (1954), **60**, 582–586. 9½″.

Some analytical properties of continuous stationary Markov transition functions. *Trans. Amer. Math. Soc.* (1955), **78**, 529–540. 10″.

Khamis, Salem H. & Powers, Leland E. Report on infant mortality survey of rural Lebanon. [Beirut,] American University of Beirut, 1955. 18 l. 11″.

King, E. P. Estimating the standard deviation of a normal population. *Industr. Qual. Contr.* (1953), **10**, no. 2. 4p. 11″.

On some procedures for the rejection of suspected data. *J. Amer. Statist. Ass.* (1953), **48**, 531–533. 9¼″.

Probability limits for the average chart when process standards are unspecified. *Industr. Qual. Contr.* (1954), **10**, no. 6. 3p. 11″.

Kuczynski, Jürgen. Die Geschichte der Lage der Arbeiter in England von 1640 bis in die Gegenwart. Dritter Teil. Seit 1832. 2te, verbesserte Auflage. Berlin, Tribüne, 1955. 352p. 8¼″. (Die Geschichte der Lage der Arbeiter unter dem Kapitalismus Band 4.)

LeCam, L. An extension of Wald's theory of statistical decision functions. *Ann. Math. Statist.* (1955), **26**, 69–81. 10″.

Lermer, Arthur. The evolution of Canadian policy towards cultural pluralism. Montreal, Canadian Jewish Congress, 1955. 12 l. 11″. (Information and Comment: social and economic studies No. 16.)

Lieblein, Julius. On the exact evaluation of the variances and covariances of order statistics in samples from the extreme-value distribution. *Ann. Math. Statist.* (1953), **24**, 282–287, 10″.

Properties of certain statistics involving the closest pair in a sample of three observations. *J. Res. Nat. Bur. Stand.* (1952), **48**, 255–268. 10¼″.

Linnig, Frederic J., Mandel, John & Peterson, Jean M. A plan for studying the accuracy and precision of an analytical procedure. *Analyt. Chem.* (1954), **26**, 1102–1110. 11¼″.

Little, Leo T., Handbook for economics students. London, Jordan, 1955. xii, 181p. 7½″. 7*s.* 6*d.*

Littlewoods Mail Order Stores. Facts and statistics. [45 l.] 10¼″. Typescript.

Lukacs, Eugene. On strongly continuous stochastic processes. *Sankhyā* (1954), **13**, 219–228. 11″.

Lukacs, Eugene & King, E. P. A property of the normal distribution. *Ann. Math. Statist.* (1954), **25**, 389–394. 10″.

Lydall, H. F. British incomes and savings. Oxford, Blackwell, 1955. xii, [iv,] 274p. 9¾″. 32*s.* 6*d.* (Institute of Statistics, monograph no. 5.)

McCloskey, Joseph F. & Trefethen, Florence N., *editors.* Operations research for management. Baltimore, John Hopkins Press, 1954. London, Cumberlege. xxiv, 409p. illus. 9″. 60*s.*

Mandel, John. Chain block designs with two-way elimination of heterogeneity. *Biometrics* (1954), **10**, 251–272. 9¼″.

Martin, W. J. The recent pattern of acute poliomyelitis in England and Wales. *Med. Offr.* (1955), **94**, 19–21. 2p. 12¼″.

Milbank Memorial Fund. Grants, fellowships and other appropriations in 1953–1954. New York, [Milbank Memorial Fund, 1955.] 24p. 9″.

Milnes, A. H. The principle of continuous testing. Manchester, Cook & Co., 1955. 17p. 10½″.

National Book League. Books about books: catalogue of the library of the National Book League. London, Cambridge University Press, 1955. x, 126p. 8½″. 10*s.* 6*d.*

National Bureau of Economic Research. The Korean War and United States economic activity, 1950–1952; [by] Bert G. Hickman ... New York, N.B.E.R., 1955. viii, 61p. 9″. $75. (Occ. Paper 49.)

Minimum price fixing in the bituminous coal industry; [by] Waldo E. Fisher [&] Charles M. James. Princeton, University Press, 1955. xxx, 523p. 9″. $10. (Conference on price research 5.)

Input-output analysis: an appraisal . . .; by the Conference on Research in Income and Wealth. Princeton, University Press, 1955. x, 374p. 9″. $7.50. (Studies in Income and Wealth 18.)

Nemschak, Franz. Zehn Jahre österreichische Wirtschaft 1945–1955. Wien, Österreichisches Institut für Wirtschaftsforschung, 1955. 75p. 9½″.

Neyman, Jerzy. The problem of inductive inference. *Commun. Pure Appl. Math.* (1955), **8**, 13–46. 10″.

Sur une famille de tests asymptotiques des hypothèses statistiques composées. *Trab. Estadist.* (1954), **5**, 161–168. 9½″.

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Digitized by Arya Samaj Foundation Chennai and eGangotri

Neyman, Jerzy & Scott, Elizabeth L. On the inapplicability of the theory of fluctuations to galaxies. *Astr. J.* (1955), **60**, 33–38. *Lick. Obs. Bull.* **531**, 125–130. 12¼″.

Oliveira, J. Tiago de. Composite distributions and its aplication [!] to some ecological problems. *Rev. Fac. Ciênc. Lisboa*, 2.*a Série-A* (1954), **3**, 171–175. 9″. (Estudos e notas do Seminário de Mathemática da Faculdade de Ciências de Lisboa 9.)

Page, E. S. Control charts with warning lines. *Biometrika* (1955), **42**, 244–257. 11¾″.

Patnaik, P. B. Report on the facilities for training and research in statistics in India. Calcutta, Indian Statistical Institute, 1955. [iv,] 132 p. 12¾″.

Pember and Boyle. British government securities in the twentieth century. Supplement [1955]. London, Pember and Boyle, 1955. [18,] 255p. 8″ × 13″. For private circulation.

Perez, Laureano Prado. Clasificación ocupacional de Cuba. La Habana, Tribunal de Cuentas, 1955. 103p. 9¼″.

Proschan, Frank. Confidence and tolerance intervals for the normal distribution. *J. Amer. Statist. Ass.* (1953), **48**, 550–564. 9¼″.

Control charts may be all right, but—. *Industr. Qual. Contr.* (1953), **9**, no. 6. 3p. 11″.

Read, D. R. Statistical methods with special reference to analytical chemistry. London, Royal Institute of Chemistry, 1951. 47p. 9″. 4*s*. 6*d*. (Lectures, monographs and reports 1951, no. 1.)

Reading. University. *Department of Agricultural Economics.* Financial results on farms in the southern province in 1951/52 and 1952/53, by G. B. Bisset. Reading, 1954. 31p. 9¾″. 5*s*. (Farm Management Survey Report 4.)

Financial results of twenty-nine poultry flocks in Southern England during 1951–1952; by J. A. Mollett. Reading, 1953. 18p. 10″. 2*s*. (Misc. Cost Studies 25.)

Costs and returns from milk production in the southern province in 1951–1952; by R. S. Cook. Reading, 1953. 22p. 10″. 2*s*. (Misc. cost studies 26.)

Costs and returns of barley production on twenty-three farms in the South of England in 1951–1952; by Ian G. Reid. Reading, 1953. 5p. 10″. 2*s*. (Misc. Cost Studies 27.)

Some economic aspects of pig production 1953–1954; by D. S. Thornton. Reading, 1955. 15p. 10½″. 2*s*. (Misc. Cost Studies 28.)

Richards, R. K. Arithmetic operations in digital computers. New York, Van Nostrand, 1955. London, Macmillan. vi, 397p. 9″. 52*s*. 6*d*.

Rijkoort, P. J. & Wise, M. E. Simple approximations and nomograms for two ranking tests. *Verh. Akad. Wet. Amst. A* (1953), **56**, 294–302. *Indag. Math.* (1953), **15**. 10¼″.

Science Council of Japan. *Division of Economics and Commerce.* Economic series No. 1. Business cycles in post-war Japan; by Shigeto Tsuru. Tokyo, Science Council of Japan, 1953. [ii,] 34p. 8½″.

No. 2. On cultural conditions affecting population trends in Japan; by Nomura Kanetaro. Tokyo, 1953. [iv,] 35p. 8½″.

No. 3. Essays in public finance; by Hanya Ito. Tokyo, 1954. [viii,] 112p. 8½″.

No. 4. The historical development of economic dynamics: a memorandum; by Shin-ichi Ichimura. Tokyo, 1955. [viii,] 37p. 8½″.

No. 5. Level of living in Japan; by Hiromi Arisawa: Tokyo, 1955. [x,] 51p. 8½″.

No. 6. Japan's trade and her level of living; by Shigeru Fujii. Tokyo, 1955. [viii,] 76p. fold. diagr. 8½″.

Seliger, Howard H. A new method of radioactive standard calibration. *J. Res. Nat. Bur. Stand.* (1950), **45**, 496–502. 10¼″.

Spicer, C. C. The theory of bacterial constant growth apparatus. *Biometrics* (1955). **11**, 225–230. 9¼″.

Spiegelman, Mortimer. Introduction to demography. [Chicago,] Society of Actuaries, 1955. xxi, 309p. 2 fold. tables. 9″. $6. (Society of Actuaries textbook.)

Staples, Ronald, *editor.* Taxation key to income tax and surtax, 1955–56. London, Taxation Publishing Co., 1955. 223p. 8½″. 10*s*.

Stiehler, R. D., Richey, G. G. & Mandel, J. Measurement of treadwear of commercial tires. *Rubb. Age, N.Y.* (1953), **73**, no. 2. [8p.] 11″.

Studi in onore di Gaetano Pietra. [Bologna,] Capelli, 1955. 766p. port., 4 fold. tables. 9½″. *L*.4000.

Tate, Robert F. The theory of correlation between two continuous variables when one is dichotomized. *Biometrika* (1955), **42**, 205–222. 10¾″.

Thrall, R. M., Coombs, C. H. & Davis, R. L. Decision processes. New York, Wiley, 1954. London, Chapman & Hall. viii, 332p. 8″. 40*s*.

Uppsala. *University Institute of Statistics.* Selected publications. [Uppsala, 1955.] 9¼″. 15 papers by Prof. H. O. Wold & others.

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Digitized by Arya Samaj Foundation Chennai and eGangotri

Wald, Abraham. Selected papers in statistics and probability. New York, London, [etc.] McGraw-Hill, 1955. x, 702p port. 10″. 60*s*.

Westing, J. H., Knight, W. D. *and others.* The area of effectiveness of a selected VHF television station: a case study based on WBAY–TV, Green Bay. Madison, Wisconsin University, 1955. 65p. maps. 11″. $1.15. (Wisconsin Commerce Reports v. 4, no. 2.)

Wise, M. E. Converting a number distribution of particle size into one for volume or surface area. *Philips Res. Rep.* (1954), **9**, 231–237. 7p. 9″.

A quickly convergent expansion for cumulative hypergeometric probabilities, direct and inverse. *Biometrika* (1954), **41**, 317–329. 10¾″.

The ratio of two factorials and some fundamental probabilities. *Verh. Akad. Wet. Amst. A* (1954), **57**, 513–521. *Indag. Math.* (1954), **16**. 9¾″.

Wishart, John. Multivariate analysis. *Appl. Statist.* (1955), **4**, 103–116p. 9¾″.

Working, Holbrook. Price effects of scalping and day tradings. *Proc. 7th Annual Symposium, Commodity Markets and the Public Interest, Chicago Board of Trade* (195–), 113–139. Port. 11″.

Yates, Frank. The analysis of experiments containing different crop rotations. *Biometrics* (1954), **10**, 324–346. 9¼″.

Youden, W. J. Comparative tests in a single laboratory. *Bull. Amer. Soc. Test. Mat.* (1950), no. 166, 48–51. 11¼″.

The Fisherian revolution in methods of experimentation. *J. Amer. Statist. Ass.* (1951), **46**, 47–50. 9¼″.

The interpretation of chemical data. *Industr. Qual. Contr.* (1952), **8**, 90–93. 4p. 11″.

Locating sources of variability in a process. *Industr. Engng. Chem. (Industr.)* (1951), **43**, 2059–2062. 11″.

A note on the four by four latin squares. *Biometrics* (1950), **6**, 289–290. 9¼″.

Sets of three measurements. *Sci. Mon., N.Y.* (1953), **77**, 143–147. 10¼″.

Statistical aspects of analytical determinations. *Analyst* (1952), **77**, 874–878. 9¾″.

Youden, W. J. & Cameron, J. M. Use of statistics to determine precision of test methods. *Symp. Appl. Statist.* (1950), 27–34. 9″.

Youden, W. J. & Connor, W. S. The chain block design. *Biometrics* (1953), **9**, 127–140. 9¼″.

Making one measurement do the work of two. *Chem. Engng. Progr.* (1953), **49**, 549–552. 11¼″.

New experimental designs for paired observations. *J. Res. Nat. Bur. Stand.* (1954), **53**, 191–196. 10¼″.

Zagoroff, S. D. National income and general productivity in terms of energy. *Schweiz. Z. Volksw.* (1955), **91**, 91–107. 9½″.

Zelen, Marvin. Analysis for some partially balanced incomplete block designs having a missing block. *Biometrics* (1954), **10**, 273–281. 9¼″.

A note on partially balanced designs. *Ann. Math. Statist.* (1954), **25**, 599–602. 10″.

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REVENUE OF THE UNITED KINGDOM

Net Produce in Quarters of 1954, *and the Financial Years ended March* 31, 1953/54, 1952/53, 1951/52, 1950/51

£ thousand

	Quarters ended				Total for Calendar Year 1954
	March 31, 1954	June 30, 1954	Sept. 30, 1954	Dec. 31, 1954	
Ordinary Revenue—	£	£	£	£	£
Income tax	1,087,239	218,754	250,375	206,365	1,762,733
Surtax	82,400	20,900	11,000	18,200	132,500
Death duties	42,700	44,800	46,400	45,800	179,700
Stamps	15,000	16,400	18,270	20,900	70,570
Profits tax and excess profits tax	43,600	29,500	54,300	47,000	174,400
Excess profits levy	17,800	14,700	30,500	16,850	79,850
Other Inland Revenue duties	620	350	330	150	1,450
Total Inland Revenue	1,289,359	345,404	411,175	355,265	2,401,203
Customs	244,716	275,390	280,199	287,098	1,087,403
Excise	173,220	167,140	192,895	211,033	744,288
Total Customs and Excise	417,936	442,530	473,094	498,131	1,831,691
Motor vehicle duties	54,634	8,067	6,832	5,700	75,233
Post Office (net receipt)	—	—	600	600	1,200
Broadcasting receiving licences	5,500	3,850	3,600	7,550	20,500
Receipts from sundry loans	17,703	2,838	16,814	1,109	38,464
Miscellaneous receipts	40,456	34,976	31,841	65,605	172,878
Total Ordinary Revenue	1,825,588	837,665	943,956	933,960	4,541,169
Self-balancing Revenue—					
Post Office	63,200	57,000	60,400	67,200	247,800
Income tax deducted from excess profits tax, post-war refunds	641	941	926	1,156	3,664

£ thousand

	Year 1953/54	Year 1952/53	1953/54 (compared with 1952/53)		Corresponding Years	
			Increase	Decrease	1951/52	1950/51
Ordinary Revenue—	£	£	£	£	£	£
Income tax	1,730,991	1,736,233	—	5,242	1,668,749	1,404,364
Surtax	132,400	131,200	1,200	—	129,600	121,100
Death duties	164,500	151,850	12,650	—	183,000	185,250
Stamps	56,600	50,250	6,350	—	61,900	54,460
Profits tax and excess profits tax	188,400	376,100	—	187,700	315,400	267,770
Excess profits levy	65,850	2,950	62,900	—	—	—
Other Inland Revenue duties	1,390	2,020	—	630	3,270	5,445
Total Inland Revenue	2,340,131	2,450,603	—	110,472	2,361,919	2,038,389
Customs	1,042,396	1,024,498	17,898	—	998,497	905,216
Excise	721,975	739,093	—	17,118	753,285	724,800
Total Customs and Excise	1,764,371	1,763,591	780	—	1,751,782	1,630,016
Motor vehicle duties	73,115	67,658	5,457	—	65,211	61,357
Surplus receipts from certain trading services	—	—	—	—	75,455	80,905
Post Office (net receipt)	—	—	—	—	—	962
Broadcasting receiving licences	16,400	14,800	1,600	—	14,150	13,000
Receipts from sundry loans	38,014	24,681	13,333	—	25,393	26,876
Miscellaneous receipts	136,099	117,382	18,717	—	139,481	126,319
Total Ordinary Revenue	4,368,130	4,438,715	—	70,585	4,433,391	3,977,824
Self-balancing Revenue—						
Post Office	232,000	209,900	22,100	—	190,050	171,088
Income tax deducted from excess profits tax, post-war refunds	5,940	5,192	748	—	5,525	8,347

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INDEX TO VOL. 118.

YEAR 1955

(Statistical and Current Notes are indicated by the letters S.N. and C.N. respectively.)

PAGE

ADDITIONS to the Library 131, 268, 380, 506

AGRICULTURAL income. *See* BELLERBY (J. R.)

ANDREW (J. E.). *See under* LANE (K. F.)

ANNUAL General Meeting, Proceedings of 121st, 1955 483

BANK OF ENGLAND, Weekly returns . . 138–139

BIRTHS, deaths and marriages. *See* REGISTRATION.

BELLERBY (J. R.). Agricultural income . 336–344

BOOKS. Reviews and notices of statistical and economic books.

Abdel-Atly (S. H.). Tables of generalized *K*-statistics 365

Bartlett (M. S.). An introduction to stochastic processes 484

Blackwell (D.) and Girshick (M. A.). Theory of games and statistical decisions . . 102

Bliss (C. I.) and Calhoun (D. W.). An outline of biometry 107

Booth (Andrew D.). Numerical methods . 249

Carter (C. F.) and Roy (A. D.). British economic statistics 111

Colerus (E.). From simple numbers to the calculus 364

Conference on research in income and wealth. Short-term economic forecasting . . 368

Cox (P. R.). Addendum to demography—developments during 1949–54 . . 367

Cramér (H.). The elements of probability theory and some of its applications . . 486

Crawford (J. G.) and others. Wartime agriculture in Australia and New Zealand, 1939–1950 118

Davies (O. L.) ed. Design and analysis of industrial experiments 101

Economic Commission for Europe, Transport Division. Annual bulletin of transport statistics, 1953 (S.N.) 261

Enrick (N. L.). Quality control. 2nd ed. . 109

Eysenck (H. J.). The psychology of politics . 108

Festinger (Leon) and Katz (Daniel) (ed. by). Research methods in the behavioral sciences 246

Fisher (Sir Ronald). Statistical methods for research workers. 12th ed. . . . 486

Fox (L.). A short table for Bessel functions of integer orders and large arguments . 106

Glass (D. V.) and Grebenik (E.). The trend and pattern of fertility in Great Britain: a report on the family census of 1946 . 251

Gnedenko (B. V.) and Kolmogorov (A. N.). Limit-distributions for sums of independent random variables 248

Goldsmith (R. W.). A study of saving in the United States. Vols. I and II . . 370

Hegeland (H.). The multiplier theory . 250

Hill (A. Bradford). Principles of medical statistics 6th ed. 487

Hoel (P. G.). Introduction to mathematical statistics. 2nd ed. 103

Hogben (L.). Chance and choice by cardpack and chessboard 485

International Council for building research studies, Bulletins, 1954. S.N. . . . 122

International Labour Office. Year Book of Labour Statistics (S.N.). 260

PAGE

International Labour Office. Systems of social security: United States (S.N.) . 261

International research in accounting (S.N.) . 122

Isaac (Julius). British post-war migration . 253

Jefferys (J. B.). Retail trading in Britain, 1850–1950 118

Jensen (A.). A distribution model applicable to economics 490

Kempthorne (Oscar) and others (ed. by). Statistics and mathematics in biology . 247

Kuczynski (J.). Die Geschichte der Arbeiter in England. Part I 1640–1760, Part II 1760–1832 (new ed.) (S.N.) 374

Leibenstein (H.). A theory of economic-demographic development. . . . 367

Market Research Society. Readership Surveys, No. I 123

Masuyama (M.). Graphical method of statistical inference 489

Miller (J. C. P.) (ed.). Table of binomial coefficients 106

National Bureau of Standards: Applied mathematics series—Tables of Langrangian coefficients for sexagesimal interpolation; tables of secants and cosecants to nine significant figures at hundredths of a degree . 105

——— Statistical theory of extreme value and some practical applications; probability tables for the analysis of extreme value data 106

———. Computer development (SEAC and DYSEAC) at the Bureau . . 366

———. Tables of sine and cosine integrals for arguments from 10 to 100. Table of the gamma function for complete arguments . 365

National Food Survey Committee. Domestic food consumption and expenditure, 1952 (S.N.) 259

Neisser (Hans) and Modigliani (Franco). National incomes and international trade 255

Organisation for European economic co-operation. Industrial censuses in the United States 491

———. Private United States investment in Europe and the overseas territories . 492

———. Sixth report. From recovery towards economic strength. Vol I . . 369

———. Statistics of national product and expenditure, 1938, 1947 and 1952 . . 252

Pearson (E. S.) and Hartley (H. O.) (ed.). Biometrika tables for statisticians, Vol. I. . 103

Prest (A. R.) and Adams (A. A.). Consumers' expenditure in the United Kingdom, 1900–1919 114

——— and Stewart (I. G.). The national income of Nigeria, 1950–51 . . . 371

Rand Coporation. A million random digits with 100,000 normal deviates . . 364

Richardson (J. H.). An introduction to the study of industrial relations . . 116

Rios (S.). Introduccion a los metodos de la estadistica. Part 2 110

Roll (Eric). A history of economic thought. 3rd ed. 256

Roose (K. D.). The economics of recession and revival 113

Savage (L. J.). The foundations of statistics 245

Stone (R.), Rowe (D. A.) and Corlett (W. J.). Measurement of consumers' expenditure and behaviour in the United Kingdom 1928–1938. Vol I. 114

Theil (H.). Linear aggregation of economic relations 363

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PAGE

Toronto meteorological conference, 1953, Proceedings . . . 112
United Nations. The international flow of private capital, 1946–52 . . . 113
———. Statistical year book, 1954 (S.N.) . 260
U.N.E.S.C.O. The university teaching of the social sciences (S.N.) . . . 374
Wald (A.). Selected papers in statistics and probability 488
Williams (J. D.). The compleat strategyst . 250
World Health Organisation, bulletin special number (Health Statistics Conference, 1953) (S.N. 261

BROCKS (B. J.). Statistics available on the Local Government Services . . 234–244
Financial statistics: Local government financial statistics; return of rates; miscellaneous financial statistics of counties . . 234
"Welfare" services of county boroughs; fire and police; housing . . . 237
Rating; debt 238
Non-finacial statistics: Ministry of education; Ministry of health; Home Office; Ministry of housing and local government; transport; non-governmental statistics; statistics of individual authorities . 240

CLINICAL Services. Statistical assessment of the need for 427–433
COLLIERY statistics. *See* LIDDELL (F. D. K.).
COX (D. R.). The statistical analysis of congestion 324–335
COUNCIL, Report of, for the financial year ended Dec. 31, 1954, and the sessional year ended June 22, 1955 . . 465–482
CURRENT Population Problems. *See* POPULATION problems.

ELECTIONS to Fellowship 10, 27, 192, 223, 295, 323, 404, 483
ELECTIONS to Honorary Fellowship . . 483
EMPLOYEE population, age analysis . . 374
EMPLOYMENT 121, 258, 373, 494

FARM wages in Scotland, 1814–1870. *See* HOUSTON (George)
FINANCIAL investment, statistics bearing on. MASON (J. I.) and SACHS (D.)
FREQUENCY distributions. A unified derivation of some. *See* IRWIN (J. O.)

GREBENIK (E.). Population and vital statistics 452–462
Organisation and legislation . . . 452
Publications—census, vital registration; marriage, divorce, fertility . . . 454
Population estimated and forecasts—reproduction rates 460

HONORARY Fellows elected 1955. *See* ELECTIONS.
HOUBLON-NORMAN Fund. Awards, 1955–1956 375
HOUSTON (George). Farm wages in Central Scotland from 1814 to 1870 . 224–228

INDUSTRIAL disputes in 1954 . . . 374
INTERNATIONAL Statistical Institute, 29th Session, Rio de Janeiro, Brazil, 1955 . 463
INVESTMENT. Net investment in fixed assets in the United Kingdom, 1938–1953. *See* REDFERN (Philip).
———. Statistics bearing on financial investment. *See* MASON (J. I.) and SACHS (D.).

PAGE

IRWIN (J. O.). A unified derivation of some well-known frequency distributions of interest in biometry and statistics . 389–398
The matching distribution . . . 390
Distribution of number of occupied classes when n objects are assigned randomly to k different classes 391
Distribution of the greatest interval when a line of fixed length is divided into n intervals by $(n-1)$ randomly placed points . 393
Application to Schuster's criterion in periodogram analysis 396
Discussion: Dr. Wishart; Dr. Isserlis; Dr. F. N. David; Dr. D. E. Barton; Mr. J. C. Tanner; Dr. Irwin in reply . 399–404

JEVONS, Professor Stanley. Obituary notice 498

KHANDKER (R. H.). The pattern of a divided economy: a national income analysis of India and Pakistan . . 51–55

LANE (K. F.) and ANDREW (J. E.). A method of labour turnover analysis . 296–314
Summary and introduction . . . 296
Method: basis—turnover rates—probability of leaving functions . . . 297
Applications: collection and examination of data at United Steel Companies Ltd. . 301
Log-normal distributions . . . 307
Factors influencing labour stability . . 309
Time changes 313
Conclusion 314
Discussion: Mr. B. Benjamin; Mr. Spratling; Mr. J. Aitchison; Mr. H. Silcock; Mr. A. J. H. Morrell; Mr. F. J. Lloyd; The authors in reply . . 314–322
LIDDELL (F. D. K.). Colliery statistics . 405–413
The colliery profile 406
The diverse nature of the industry . . 407
Size and performance . . . 410
Measuring performance . . . 412
Summary and conclusions . . . 413

LOCAL Government services, Statistics on. *See* BROCKS (B. J.).
LOTTERY numbers, an analysis of. *See* WEST (John (H.).
LYLE (Philip). Obituary notice . . 497

MACMILLAN Gap and the shortage of risk capital. *See* PIERCY, LORD.
MASON (J. I.) and SACHS (D.). Statistics bearing on financial investment . 67–98
General indicators of Stock Exchange investment activity 68
Financial analyses of an industrial character . 84
Statistics of individual concerns or special groups 91
Broad economic data concerning companies; investiment holdings, personal savings, etc. 92
Gaps and projected research; references . 97

MATHEMATICAL Statistics, the teaching of. *See under* TEACHING.
MEASURING social mobility. *See* PRAIS (S. J.).
MEASURING unemployment. *See* TURNER (H. A.).
METHOD of Labour turnover analysis. *See* LANE (K. F.) and ANDREW (J. E.).

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PAGE

NATIONAL income and related statistics. *See* UTTING (J. E. G.).
——— of India and Pakistan. *See* KHANDKER (R. H.).
NET investment in fixed assets in the United Kingdom, 1938–1953. *See* REDFERN (Philip).

OBITUARY—
Professor Stanley Jevons . . . 498
Philip Lyle 497
Dr. L. Rostas 124
B. Seebohm Rowntree 125
George Findlay Shirras 499

PATTERN of a divided economy, The. *See* KHANDKER (R. H.).
PIERCY, LORD, of Burford, C.B.E. The Macmillan gap and the shortage of risk capital (Inaugural Address of the President) 1–7
Proceedings of the Meeting: Professor Sir Ronald Fisher; Sir Geoffrey Heyworth; Professor A. Bradford Hill (written contribution) . . . 7–10
POPULATION and vital statistics. *See* GREBENIK (E.).
——— Problems, Current. A Discussion:
Openers: Mr. Benjamin; Prof. E. Grebenik; Dr. W. P. D. Logan; Prof. Brinley Thomas; Mr. J. Hajnal; Dr. J. A. Fraser Roberts . . . 12–24
Subsequent speakers: Colin Clark; S. Singh; (written comment) P. R. Cox, R. H. Daw; Professor Grebenik and Dr. Logan in reply . . . 25–27
PRAIS (S. J.). Measuring social mobility . 56–66
PRICES, Retail 121, 258, 373, 494
PRICES, Wholesale, in 1954. *See* STATIST, Editor of.

REDFERN (Philip). Net investment in fixed assets in the United Kingdom, 1938–1953 141–182
The problems and the solution proposed . 142
Special problems which arise in applying this solution 144
Scope of the estimates and methods employed 149
Results: including tables of gross and net fixed capital formation in each industry group and in individual industries . . . 151
Appendices: A. The price indices . 169
B, C. Definitions of the industries—length of life—sources of estimates . . 173
Discussion: Mr. W. A. B. Hopkin; Mr. R. G. Glenday; Mr. J. Stafford; Mr. H. C. Cottrell; Mr. H. G. Clarke; Mr. C. T. Saunders; Mr. T. K. Gribbin; The President; Mr. R. E. Beales: and Mr. Redfern in reply . . . 182–192
REGISTRATION of the United Kingdom and Eire, 1950–54 384–387
REVENUE of the United Kingdom, 1954 . 514
ROSTAS (L.). Obituary notice . . 124
ROWNTREE (B. Seebohm). Obituary notice 125

SACHS (D.). *See under* MASON (J. I.).
SCOTCH whisky industry. *See* WILSON (Ross).
SHIRRAS, George Findlay. Obituary notice 499

PAGE

SICKNESS and industrial injuries, absence due to 122, 259, 374, 495
SOCIAL mobility, measuring. *See* PRAIS (S. J.).
STATIST, THE, Editor of. Wholesale prices in 1954 229–233
Method of construction of the index numbers 229
Annual and monthly index numbers, 1902–11 to 1954 229–30
Average prices of each of the 45 commodities . 231–32
Index of silver prices; gold and silver production 233
STATISTICAL Assessment of the need for clinical services: report of a working group 427–433
STATISTICAL and economic articles in recent periodicals . . . 127, 263, 376, 501

TEACHING of mathematical statistics at university level. A Discussion:
Openers: Professor E. S. Pearson; Dr. J. Wishart; Professor G. A. Barnard; Professor M. S. Bartlett; Professor D. G. Champernowne; Dr. D. J. Finney 193–213
Subsequent speakers: Professor M. G. Kendall; Mr. I. D. Hill; Dr. Johnson; Miss E. J. Warner; Miss Keen; Mr. Watkins; Dr. G. H. Jowett; Mr. Halton Thomson; Dr. D. A. Evans; Mr. Liddell; Dr. Haskey; Mr. J. C. Eaton; (in writing) Mr. R. L. Plackett, Dr. E. S. Page, Mr. G. M. Clarke . . 213–223
THOM (A.). A statistical examination of the megalithic sites in Britain . . 275–291
Geometry of the circles . . . 275
The circle diameters . . . 280
Astronomical significance of the megalithic remains—outliers and alignments . . 283
Conclusion 289
Discussion: Professor M. G. Kendall; Mr. S. R. Broadbent; Professor Gordon Childe; Dr. Irwin; Professor Thom in reply 291–295
TRADE Unions membership . . . 122
TURNER (H. A.). Measuring Unemployment 28–50
The indices 28
Short time and overtime . . . 30
Underemployment 34
"Unemployment" 38
"Holidays" 42
Summary and conclusions . . . 44

UNEMPLOYMENT figures . . 122, 258, 373, 494
——— *See also under* TURNER (H. A.).
UNIFIED derivation of some well-known frequency distributions. *See* IRWIN (J. O.).
UTTING (J. E. G.). National income and related statistics 434–451
Definitions 436
Social accounts 441
Input-output statements . . . 441
Comparisons over time . . . 446
International comparisons . . . 448
Other recent estimates . . . 448

WAGES 121, 258, 373, 494
WEST (JOHN H.). An analysis of 162,332 lottery numbers 417–426
WILSON (Ross). The Scotch whisky industry 345–362

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